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ABSTRACT

This study investigated the relationships between the mathematical problem-solving performance of fourth-grade children, their attitudes toward problem solving, their teachers' attitudes, and related sex and program-type differences. Three instruments were used to gather data. Data were gathered for the first part of the study from 30 classes in thirteen southern Wisconsin schools. Half used Developing Mathematical Processes (DMP); the remaining used standard textbooks. Results showed DMP students performed significantly better than non-DMP pupils on the first two parts of the problem-solving instrument, with no significant differences on the third part. Among other results, no significant sex-related differences were found. Data for part one was collected during the fourth month of the 1975-76 school year. Part two was conducted during the seventh month only with the DMP classes, in an attempt to determine direction of effects between teacher attitudes and student attitudes and performance. It is noted that initial teacher attitude seemed to have a greater effect on final student attitude than initial student attitude had on final teacher attitude. (MP)

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TECHNICAL REPORT NO. 396
(Part 1 of 2 Parts)

a study of the relationships between selected noncognitive factors and the problem solving performance of fourth-grade children

SEPTEMBER 1976

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Technical Report No. 396
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A STUDY OF THE RELATIONSHIPS BETWEEN SELECTED NONCOGNITIVE FACTORS AND THE PROBLEM SOLVING PERFORMANCE OF FOURTH-GRADE CHILDREN

by

Donald Ray Whitaker

Report from the Project on
Conditions of School Learning and Instructional Strategies

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Madison, Wisconsin

September 1976

This Technical Report is a doctoral dissertation reporting research supported by the Wisconsin Research and Development Center for Cognitive Learning. Since it has been approved by a University Examining Committee, it has not been reviewed by the Center. It is published by the Center as a record of some of the Center's activities and as a service to the student. The bound original is in the University of Wisconsin Memorial Library.

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ABSTRACT

The purpose of this study was to investigate the relationships between the mathematical problem solving performance of fourth grade children, their attitudes toward mathematical problem solving, their teachers' attitudes toward mathematical problem solving, and related sex and program-type differences.

Three instruments were used to gather data. The 22-item mathematical problem solving test (Romberg & Wearne, 1976) provides a measure of comprehension, application, and problem solving for each item. The 36-item student mathematical problem solving attitude scale and the similar 40-item teacher scale have Likert-type formats and were developed by the investigator.

During the fourth month of the 1975-76 school year data were gathered for Part I of the study from 30 fourth grade classes in 13 southern Wisconsin schools. Fifteen of the classes were using Developing Mathematical Processes (DMP); the remaining 15 were using standard mathematics textbook series.

Both students and teachers possessed favorable mathematical problem solving attitudes. The DMP students performed significantly better than non-DMP students on the first two parts of the problem

solving test; no significant differences in performance were observed on the third part. Rather stable and significant positive correlations were found between student problem solving performance and student problem solving attitude. Significant negative correlations found between DMP teacher problem solving attitude and mean student performance were judged an artifact of the non-random sampling of classes for the study. No significant sex-related differences were found in any of the data.

The design of Part II of the study was based on the cross-lagged panel correlational technique of Campbell and Stanley (1963). During the seventh month of the 1975-76 school year the 15 DMP classes participated in a second round of problem solving testing. An intervening "treatment" period between the first and second testing times involved instruction in selected DMP topics. Part II attempted to determine the direction of effect between teacher problem solving attitudes and student problem solving attitudes and performance.

Cross-lagged panel correlations indicated that initial student performance seemed to have a greater effect on final teacher attitude than initial teacher attitude had on final student performance. However, initial teacher attitude seemed to have a greater effect on final student attitude than initial student attitude had on final teacher attitude.

Major Professor John G. Harvey

Chapter 1

INTRODUCTION

One of the goals of education in a democratic society is to produce citizens capable of intelligent, independent thought. Citizens must be able to tackle, cope with, and see problems through to reasonable, if not logical, solutions. Educators continually strive to achieve that goal within their respective disciplines. In elementary and secondary mathematics education in the United States, the attainment of that goal has been bolstered by a large and sustained curriculum reform effort during the past two decades. This curriculum reform movement has included a number of experimental programs concerned with the development of new methods of teaching mathematics. Underlying both the curriculum reform efforts and the teaching experimentation has been the belief that mathematics is not something which is passively learned, but is something which people do. Specifically, mathematics is chiefly concerned with the solving of a large variety of problems.

The investigation of problem solving, and of related and influencing factors, has occupied a great deal of the time and energy of educational researchers. Many variables have been presumed to be related to the activity necessary for success in solving problems. Among these variables are attitudes, values, interests, appreciations, adjustments, temperament, and personality (Stern, 1963). These variables often have been termed noncognitive to contrast them from those associated with measures of intelligence, aptitude, achievement, or performance which, typically, are referred to as cognitive variables. The purpose of the study reported in this paper was to investigate the relationships between selected noncognitive factors and the mathematical problem solving performance of fourth grade children.

Of the vast number of psychological investigations which have studied problem solving, only a small number have concentrated on mathematical problem solving. Kilpatrick (1969) has remarked that the topic of mathematical problem solving has not been investigated systematically. A close examination of the problem solving research in elementary school mathematics shows a diversity of types of investigations and conflicting results (see Riedesel, 1969; Suydam, 1967; Suydam & Weaver, 1971-75).

However unsystematic their methods of attack, researchers continue to investigate problem solving for a variety of reasons. Dodson (1972) summarizes some of these reasons:

> Appropriately, then, researchers have been stimulated to investigate problem solving to gain a better understanding of the nature of effective problem solving, to determine the effects of problem solving on student attitudes, to find methods for improving problem-solving ability, to learn more about how problem-solving ability

> is acquired and how the cognitive processes are involved, and to determine the correlation of student characteristics and classroom characteristics with the ability to solve problems [p. 2].

The study reported here was directed toward several of these purposes noted by Dodson and is one in a series of closely related problem solving investigations undertaken at the University of Wisconsin (see Zalewski, 1974; Meyer, 1975; Schonberger, 1976; Wearne, in preparation).

The Nature of the Problem

Because the development of pupils' ability to solve problems is one of the primary goals of elementary mathematics instruction, educators continue to seek information about the nature of this ability; it has commonly been assessed by students' achievement on written problem solving tests. Clues regarding those noncognitive factors which many influence problem solving performance may be obtained by examining some of the factors thought to influence overall mathematics achievement.

First, students' attitudes toward a school subject are thought to affect their achievement in that subject. Likewise, educators believe that teachers' attitudes toward a subject can influence their students' attitudes and achievement in that subject. Research findings have sometimes been inconsistent and inconclusive in these areas, but, typically, show the existence of low, positive correlations between student and teacher attitudes toward mathematics and student achievement in mathematics (see Garner, 1964; Torrance, 1966; Wess, 1970; Phillips, 1973). These results also pose the somewhat traditional problem of cause and effect. Do teachers' attitudes cause student attitudes, or is the effect, perhaps, in the other direction?

Just as an individual's overall mathematics achievement consists of a composite of his or her achievement in several areas, a reasonable conjecture is that a student's attitude toward mathematics is a composite of certain aspects of mathematics such as computation and problem solving. But researchers have tended to use single, global measures of attitude toward mathematics rather than investigating attitude toward only one phase of the discipline. Lindgren, Silva, Faraco, and Da Rocha (1964) did use a measure of problem solving attitude, but correlated the attitudinal results only with arithmetic achievement and not with problem solving performance. The study reported here examined the relationships between measures of both student and teacher problem solving attitudes and student performance in mathematical problem solving.

Though research findings are varied, there is evidence to suggest the existence of sex-related differences in mathematics achievement. In a recent review of literature, Fennema (1974) concluded that no significant differences between boys' and girls' mathematics achievement are found during the early elementary school years; however, in the upper elementary school years significant differences are sometimes found and tend to favor boys when higher level cognitive tasks are measured. In a recent investigation of selected cognitive factors and problem solving, Meyer (1975) found no significant sex-related differences among fourth grade students on any of the three parts of the problem solving test used in her study. Another study by Schonberger (1976) investigated sex-related differences in seventh-graders' performance on tests of visual spatial abilities and mathematical problem solving. Schonberger found significant differences favoring boys on one problem solving subtest of three administered. These varied findings suggested investigating sex differences as an influencing factor in the present study of mathematical problem solving performance and attitudes and suggested that the study be conducted with upper elementary school students. In addition, some attitudinal research suggests that attitudes toward mathematics are formed during the intermediate grades (Fedon, 1958; Stright, 1960; Callahan, 1971). Therefore, fourth grade students and teachers were judged to be appropriate subjects for the study.

Whenever an emerging curriculum product begins to receive widespread implementation in schools, the developers of that product become interested in the comparative learning effects of their product with existing products. For a number of years, the Analysis of Mathematics Instruction Project at the University of Wisconsin Research and Development Center for Cognitive Learning has been developing a new elementary mathematics program called Developing Mathematical Processes (DMP) (Romberg, Harvey, & Moser, 1974, 1975, 1976). The DMP program is research-based and utilizes an activity-oriented approach to the teaching and learning of mathematics in grades K-6. One of the basic goals of DMP is the development of mathematical problem solving skills and processes. As a DMP staff member, the author has worked in recent years with a number of teachers and students in DMP schools and has been impressed by the manner in which DMP students attack problems and by the positive affect which both students and teachers seem to possess with regard to the DMP program (Montgomery & Whitaker, 1975). Therefore, the sample for this study involved students and teachers who had participated in the large-scale field test of DMP. And, for program comparative purposes, a non-DMP sample of students and teachers was included in the study.

Key Terminology Used in the Study

The rather complex nature of the concepts of problem solving and attitude necessitates that each be defined in a manner which adequately characterizes the concept. At the same time, the definition must permit a reasonable and practical means of assessing the concept.

Thus, for this study, a problem is a situation which presents an objective that an individual is motivated to achieve, but for which he has no immediate procedures to arrive at that objective (Zalewski, 1974). The situation in each problem is mathematical in nature. Problem solving is the process of analyzing a situation posed in a problem, producing a procedure for solving the problem, using that procedure, and achieving a solution to the problem. Mathematical problem solving performance is represented by a score on a mathematical problem solving test.

Because of the complexity of the attitude construct, researchers seldom talk about "measuring an attitude." Rather, they use procedures to measure a particular property of an attitude, such as direction, magnitude, or intensity (Scott, 1968). As used in this study, the term attitude is the predisposition of an individual to evaluate some symbol or object or aspect of his world in a favorable or unfavorable manner (Katz, 1960). In particular, attitude toward problem solving is the predisposition of an individual to evaluate factors related to mathematical problem solving in a relatively favorable or unfavorable manner and is represented by a score on an attitude scale.

The Questions of the Study and Their Significance

Brownell (1942) called a problem solving attitude a desirable educational outcome, and something possible of development. Several years later Carey (1958) found that it is possible to develop an instrument to measure attitudes toward problem solving. The first two questions that this investigation was designed to answer pertain to the kinds of attitudes possessed by the subjects of the study. Questions ancillary to the main questions of the study are included in italics immediately following each numbered question.

Question 1: Do fourth grade students have favorable attitudes toward problem solving?

Do differences in attitude toward problem solving exist if students are classified by sex?

Do differences in attitude toward problem solving exist if students are classified by mathematics program type: DMP versus non-DMP?

Question 2: Do fourth grade teachers have favorable attitudes toward problem solving?

Do differences in attitude toward problem solving exist if teachers are classified by type of mathematics program taught: DMP versus non-DMP?

Since attitudes are generally regarded as learned predispositions of an individual to evaluate some symbol or object or aspect of his world in a favorable or unfavorable manner, it is reasonable to assume that those who have a strong influence on an individual will help mold his attitudes. Therefore, before further analyses could be undertaken in the present study, it was necessary to determine the problem solving attitudes of both the students and teachers who participated in the study. Mathematics educators desire that students and teachers hold favorable attitudes toward all phases of the school program, and so the findings of the study with regard to this question help to determine if such is the case. If differences in attitude exist according to sex of the students or type of program studied, then these findings suggest a basis for future investigations into the causes of such differences. Questions 6 and 7 of this study are designed to provide information regarding the directional relationships between problem solving attitudes and problem solving performance.

Of major importance to three remaining questions of the study is the problem solving performance of the students in the study. Question 3 deals with that issue.

> Question 3: How do fourth grade students perform on a test of problem solving performance which provides measures of comprehension, application, and problem solving?
>
> *Do differences in problem solving performance exist when students are classified by sex?*
>
> *Do differences in problem solving performance exist when students are classified by mathematics program type: DMP versus non-DMP?*

Heretofore, most tests of problem solving performance have provided a total score intended to reflect a measure of each student's ability to solve problems. However, single total scores are inadequate when attempting to explain the reasons why some students are successful at solving a set of problems and others are not. For example, single total scores cannot identify those students who are able to comprehend the information given in a problem, but who are unable to apply the information and thence solve the problem; nor can single total scores identify those students who comprehend and apply the information but do not complete the solution of the problem. The problem solving test used in this study was designed to overcome such inadequacies (see Romberg & Wearne, 1976). It provides a measure of comprehension, application, and problem solving for each item included in the instrument. Because of the unique design of this test, it is possible to identify, with some degree of accuracy, those students who are problem solvers and those who are not problem solvers. As students' problem solving performance is examined, the existence of sex-related differences provides information valuable for future research investigations regarding causation. Program-related differences provide evidence upon which to base conclusions regarding the desirability of alternative programs of instruction and also provide clues regarding potential program-specific experimentation. Differences of either type contribute to a better understanding of the nature of factors which influence problem solving performance.

Merely assessing attitudes toward problem solving is an insufficient rationale to justify an extensive research investigation unless there is some reason to suspect that these attitudes are related to performance. The fourth and fifth questions of the study pertain to that relationship.

Question 4: What is the relationship between fourth grade students' attitudes toward problem solving and their performance in problem solving?

Do differences in this relationship exist if students are classified by sex?

Do differences in this relationship exist if students are classified by mathematics program type: DMP versus non-DMP?

Question 5: What is the relationship between fourth grade teachers' attitudes toward problem solving and their students' performance in problem solving?

Do differences in this relationship exist if students are classified by sex?

Do differences in this relationship exist if students are classified by mathematics program type: DMP versus non-DMP?

As noted earlier, research findings generally have indicated low positive correlations between teacher and student attitudes toward mathematics and students' performance in mathematics at the elementary school level. However, past studies have not examined the relationship between attitude and performance in a single phase of the mathematics curriculum such as problem solving. The findings of this study with regard to Questions 4 and 5 provide insights into these relationships. If problem solving attitudes and problem solving performance are highly related, then research into other specific phases of the curriculum is mandated; for example, an investigation of the relationship between performance in computational skills and attitude toward computation. If sex differences exist in this relationship, that information provides clues for future experiments regarding causation. The existence of program-related differences provides clues regarding program effectiveness in the areas of problem solving performance and problem solving attitudes.

A rather generally held belief among educators is that teacher attitude and effectiveness in a particular subject are important determiners of student attitudes and performance in that subject (Aiken, 1969). However, research findings pertaining to this belief have not been definitive. The last two questions of the study are directed at this cause-effect relationship:

> Question 6: Do fourth grade teachers' attitudes toward problem solving affect their students' problem solving performance or is the effect of the opposite nature?
>
> *Do differences exist when students are classified by sex?*
>
> Question 7: Do fourth grade teachers' attitudes toward problem solving affect their students' attitudes toward problem solving or is the effect of the opposite natute?
>
> *Do differences exist when students are classified by sex?*

The findings of the study relative to Questions 6 and 7 contribute to the extant knowledge regarding the relationships between attitudes and performance. There is reason to suspect that students' attitudes and performance might well affect teachers' attitudes, instead of the relationship being only in the other direction. It is important, then, to gain information on which source--the teacher or the student--has the greater effect on the other's attitude and performance. Simple correlational procedures cannot answer this question. However, the cross-lagged panel correlational technique (Campbell & Stanley, 1963) used for this part of the study provides information regarding the direction of the relationship between problem solving attitudes and performance. If answers to the ancillary queries related to Questions 6 and 7 are significantly different for the two sexes, this evidence suggests the need for further research regarding causes of such differences.

The answers to the questions of the study can provide educators with additional information concerning the relationships between students' attitudes and performance in mathematical problem solving and the attitudes toward problem solving of their teachers. Additionally, findings of sex-related differences can contribute to the growing body of knowledge regarding such differences in the learning and teaching of mathematics. The existence of program-related differences may suggest a need for modifications in existing elementary mathematics programs with respect to content and methodology. In any event, the findings of the study contribute to a better understanding of the nature of the problem solving process.

The research literature related to the study is discussed in the next chapter. Chapter 3 describes the design of the study, and Chapter 4 discusses the constuction and pilot test of the instruments used in the study. Chapter 5 reports the conduct of the study, and the analysis and interpretation of the data are summarized in Chapter 6. The conclusions of the study are given in Chapter 7 along with recommendations for future research.

Chapter 2

REVIEW OF RELATED LITERATURE

The study reported in this paper investigated the relationships between several curriculum variables at the elementary school level. The main variables of interest were the mathematical problem solving performance of fourth grade children, their mathematical problem solving attitudes, and the mathematical problem solving attitudes of their teachers. Ancillary variables were sex of the student and type of mathematics program studied. This chapter will discuss the literature pertinent to the investigation and is divided into three parts. First, an overview of relevant problem solving literature is given. This is followed by a discussion of attitudinal research, and the chapter ends with a section that summarizes those studies which have particular significance for an investigation of mathematical problem solving performance and mathematical problem solving attitudes.

Part I: Problem Solving

Human beings spend a great deal of their time in the activity known as problem solving, and so it is not surprising that investigations of problem solving have occupied the time and energy of psychologists, educators, and mathematicians for many years. Investigators have examined the many facets of problem solving, including solution styles and processes, problem types, internal and external conditions, and factors affecting problem solving performance. Some individuals have proposed formal models for problem solving (see Polya, 1943; Hadamard, 1945; Gagne, 1966). Comprehensive general reviews of problem solving theory and research by Davis (1966) and in the volume edited by Kleinmuntz (1966) attest to the large number of problem solving investigations which have been conducted.

Unfortunately, a great deal of the research conducted in the name of problem solving has been inconclusive, and the results are difficult to snythesize. Lucas (1972) cites some of the difficulties which are encountered as past problem solving research is analyzed:

> Consequently, the pertinent literature of psychology and education is replete with semantic ambiguities, isolated task situations, inferences from observables to unobservables, lack of consolidation of research effort, and a host of other characteristics which serve to retain in a somewhat primitive state a field which has been considerably researched. This is not to deplore the existing state of research on problem solving, but rather to point out that the complex nature of the subject practically demands that progress occur most frequently by small steps and only occasionally by giant leaps [pp. 6-7].

Lucas also includes a comprehensive review of problem solving research and theory in his study.

In the sections which follow, no attempt is made to report in detail the results of the studies cited nor to be exhaustive in the studies cited. Rather, the intent was to select from the plethora of problem solving investigations those studies which are indicative of the wide variety of variables studied.

Mathematical Problem Solving Performance

Published reviews by Suydam (1967), Kilpatrick (1969), Riedesel (1969), and Suydam and Weaver (1971-75) verify the fact that a significant number of mathematical problem solving studies have been conducted. A number of researchers have investigated mathematical problem solving as a process (see Kilpatrick, 1967; Lucas, 1972; Zalewski, 1974; Loomer, 1976). But most studies reported in the research literature are investigations of problem solving as a product; this type of problem solving is commonly referred to as verbal problem solving, that is, the solving of collections of one- or two-step mathematics problems similar to those found in textbooks.

In the present study mathematical problem solving was of interest both as a process and as a product. The problem solving process was of interest in the design of the student and teacher problem solving attitude scales. And problem solving as a product was of interest as students' mathematical problem solving performance was assessed and examined. The means of assessing the problem solving performance in the present study, however, was unlike that used in previous investigations. The mathematical problem solving test used in the study will be described in Chapter 3.

The varied means by which mathematical problem solving performance has been assessed in the past contributes to the dilemma which arises when comparing the results of research efforts. However, with that fact in mind, the next three sections summarize pertinent studies which have attempted to relate one or more instructional variables to mathematical problem solving performance.

Cognitive Factors and Mathematical Problem Solving

Since it is impossible to review all studies relating various cognitive factors and students' mathematical problem solving performance, representative examples are included here to indicate the diversity of both variables and findings. Computational ability is significantly related to problem solving ability in mathematics (Hansen, 1944; Alexander, 1960; Chase, 1960), and so is the ability to analyze problems (Keller, 1939; Alexander, 1960). Other factors found to be significantly related to problem solving performance are problem recognition (Harootunian & Tate, 1960), and knowledge and understanding of mathematical terms (Erickson, 1958; Lyda & Duncan, 1967). As might be suspected, the literature does yield evidence of a significant relationship between intelligence and problem solving ability (Engelhart, 1932; Alexander, 1960; Chase, 1960) and between reading ability and problem solving performance (Engelhart, 1932; Treacy, 1944; Harootunian & Tate, 1960).

Mathematical Problem Solving and Sex-related Factors

Researchers have investigated the difference between the problem solving performance of boys and girls, but the results of the investigations must be deemed inconclusive; some offer evidence that boys are superior to girls in problem solving ability (Neill, 1967; Sheehan, 1968), while others contend that there is no significant difference between the problem solving abilities of the two sexes (Cleveland & Bosworth, 1967; Farr, 1969). One investigator (Neill, 1967) found that better problem solving performance occurred for students with men teachers than for those with women teachers.

In a study which will be described in more detail later in this chapter, Carey (1958) concluded that when females' attitudes toward problem solving are modified in a more favorable direction, they make significant gains in problem solving performance. In a more recent study, Schonberger (1976) found significant differences favoring boys on one problem solving subtest of three administered in her investigation of spatial abilities and problem solving performance. Meyer (1975), in a factor-analytic study of selected factors and problem solving performance, found no significant sex-related differences among fourth grade students on any of the three subscales or the total scale of problem solving performance used in her study.

Noncognitive Factors and Mathematical Problem Solving

Certain noncognitive factors, notably attitudes, anxiety, interests, personality, and familial characteristics, have begun to receive more attention in research investigations related to mathematics achievement. Though there is an acknowledged interdependence between cognitive and noncognitive variables, the discussion here will deal primarily with variables not explicitly measured by tests of ability and their relationships to problem solving performance. Some studies cited below investigated the relationships between noncognitive factors and mathematical achievement, rather than problem solving performance per se; however, mathematical achievement is measured in part by problem solving subtests, and so the studies have relevance for the present discussion.

Cleveland and Bosworth (1967) and Neufeld (1968) found that mathematics achievement was associated with a sense of personal worth, freedom from withdrawal tendencies, freedom from antisocial tendencies, social skills, and social standards. Jonsson (1965) reported that problem solving performance of highly anxious students was detrimentally affected by increasing the difficulty of test problems on the second of two tests. In an international study, Husén (1967) found that achievement in mathematics was positively correlated at all levels, both within and between countries, with interest in mathematics. The effect of socioeconomic status on students' problem solving ability has not been clearly established; Cleveland and Bosworth (1967) and Husén (1967) claimed that high achievement is associated with high socio-economic status, while Karas (1964) and Alexander

(1960) concluded that no significant relationship exists between the two variables.

Researchers have also investigated the relationship between problem solving ability and certain environmental variables, such as teaching experience (Hurst, 1968), graduate training of teachers (Leonhardt, 1963), student grades in school subjects and deportment (Morton, 1928). However, little or no consensus is reached on the significance of these variables to problem solving ability.

Concluding Remarks

The inconclusive or conflicting nature of research on those factors which influence problem solving performance documents the need for additional research studies. In particular, the two attitudinal factors examined in the present study have not been studied simultaneously with each other or with mathematical problem solving performance; hence, the results of this investigation contribute to an area in which research evidence has been inconclusive. The next section of this chapter is an overview of the literature related to the investigation of attitudes.

Part II: Attitudes

For many years the concept of attitude has been considered a subject suitable for study by psychologists. Allport (1967) credits Thomas and Znaniecki (1918) with instigating the study of the concept when they analyzed the lives of Polish immigrants to the United States. Wagner (1969) indicates that the value of attitudinal studies lies in the implications which such investigations possess for the analysis of complex human behavior. Both the psychological and educational literature are replete with attitudinal studies varying considerably in research design, in methodology, and in conclusions and implications for a clearer understanding of the concept. The next several paragraphs of this section discuss the nature of attitudes.

The Nature of Attitudes

Though numerous definitions of attitude have been advanced (see Allport, 1967), most indicate that an attitude is a learned state of readiness, a predisposition to react in a particular way toward certain stimuli. Important to any study of attitudes is the idea that an attitude involves both cognitive and noncognitive components--that is, both beliefs and feelings--and, to some extent, a behavioral component. A student's attitude toward mathematics is, for example, a composite of intellectual appreciation for the subject coupled with emotional and behavioral reactions to it.

In a condensation of recent theoretical formulations about the nature of attitudes, Scott (1968) suggests that the concept has, perhaps, 11 variable properties: direction, magnitude, intensity, ambivalence, salience, affective salience, cognitive complexity, overtness, embeddedness, flexibility, and consciousness.

Of particular importance to the assessment of attitudes toward a school subject area, such as mathematics, are the dimensions of direction (Does the individual generally like or dislike mathematics?) and intensity (How strongly does the individual feel about this attitude?)

The variable properties suggested by Scott are in keeping with the attitudinal theory espoused by Rosenberg and Hovland (1960). This theory suggests that an attitude consists of affective, cognitive, and behavioral components. A schematic conception of the Rosenberg and Hovland model is presented in Figure 2.1. This model provides a conceptual framework for organizing a study of attitudes such as that undertaken in the present investigation. In this study the measurable independent variable or stimulus is that of mathematical problem solving; the intervening variable is attitude toward mathematical problem solving, which has a subsequent relationship to an individual's affect, cognition and behavior; and the measurable dependent variables are verbal statements pertaining to an individual's affect, beliefs, and behavior with respect to mathematical problem solving.

With a conceptual framework for a study of attitudes established, the next area of concern is that of measurement of the attitude. The next several paragraphs discuss that issue.

The Measurement of Attitudes

A number of techniques are available to measure attitudes.

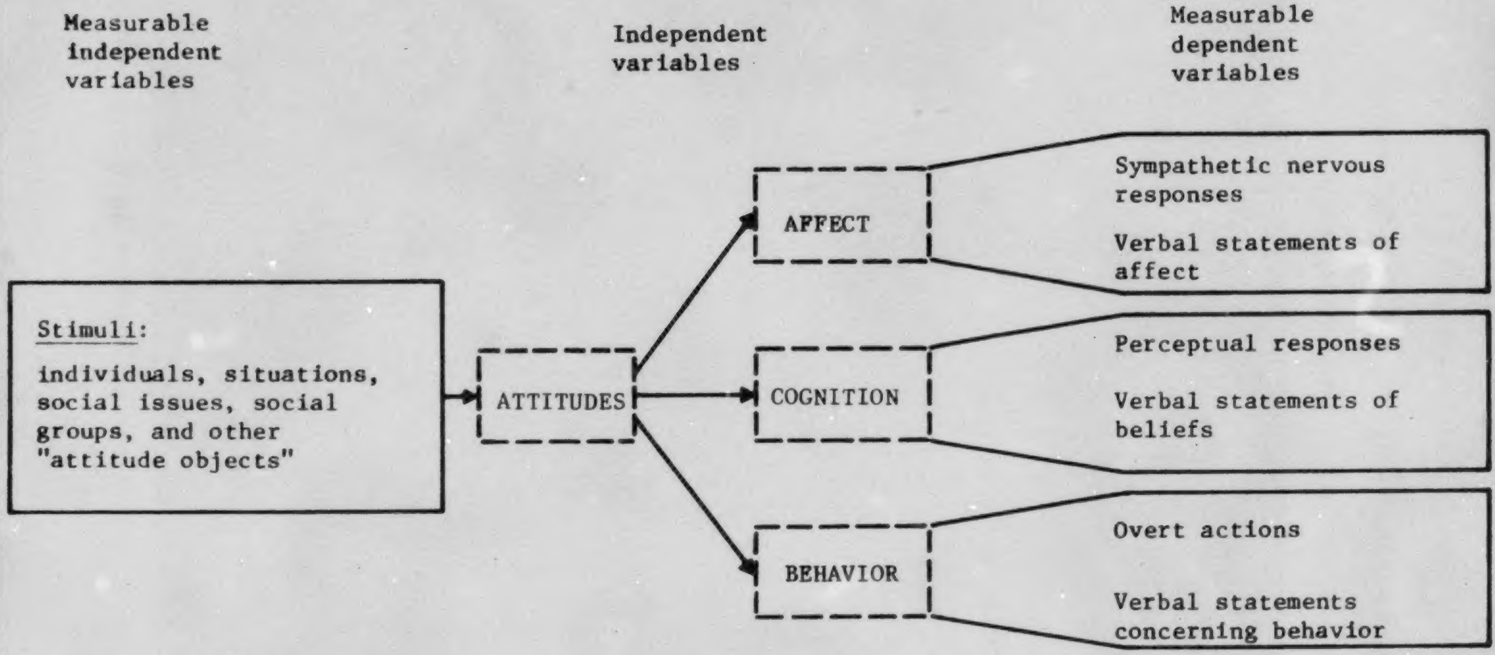

Measurable independent variables
Independent variables
Measurable dependent variables
Stimuli:
individuals, situations, social issues, social groups, and other "attitude objects"
ATTITUDES
AFFECT
COGNITION
BEHAVIOR
Sympathetic nervous responses
Verbal statements of affect
Perceptual responses
Verbal statements of beliefs
Overt actions
Verbal statements concerning behavior

Figure 2.1. A schematic conception of attitudes.

Corcoran and Gibb (1961) describe several of those used to measure attitudes toward mathematics, including questionnaires, attitude scales, incomplete sentences, projective pictures, essays, observational methods, and interviews. Of these techniques, perhaps the most widely used are the attitude scales. The most popular types of scales are described below.

A Thurstone attitude scale consists of a series of statements representing all degrees of opinion. The respondent indicates with which statements he agrees. Each statement is assigned a scale value, ranging from 0.0 for the most extreme statement possible in the negative direction, through 5.5 for neutral statements, to 11.0 for the most extremely favorable statement possible. The score for each respondent is the mean scale value of the statements checked. After the scores have been determined for each respondent, a frequency distribution can be plotted for the attitudes of any particular group (Thurstone, 1928).

As a result of their work in experimental semantics, Osgood, Suci, and Tannenbaum (1957) have developed an approach and rationale for attitude measurement known as the semantic differential. It is an attempt to obtain an indication of the overall feeling held by a group about a concept. Their technique uses bipolor adjective scales which form a continuum with positive to negative connotation. The respondent indicates his degree of feeling about the rated object by checking an appropriate descriptive term along the continuum. The semantic differential aims at a generalized feeling rather than a specific delineation of opinion.

A Likert scale (Likert, 1932) resembles a simple questionnaire, except that more refined techniques of item selection improve the instrument. The scale is a series of statements, each either definitely favorable or definitely unfavorable to the object of the scale. The respondent indicates reaction to each statement, usually on a five-point scale: strongly agree, agree, undecided, disagree, and strongly disagree. The responses are coded 5, 4, 3, 2, and 1, respectively, for favorable statements, and 1, 2, 3, 4, and 5, respectively, for unfavorable statements. A high score indicates a favorable attitude, and a low score indicates an unfavorable attitude. Apart from its relative ease of construction, the Likert scaling technique was chosen for use in this study for two reasons. First, it gives more precise information about the respondent's degree of agreement or disagreement, thus contributing more information about the important attitudinal dimension of intensity. And second, it becomes possible to include items whose content is not obviously related to the attitude in question, so that the more subtle ramifications of the attitude can be examined.

Among other, but less popular, means of assessing attitudes are biographical and essay studies (Campbell, 1950) and the monitoring of galvanic skin responses of subjects (Cooper & Pollock, 1959). Still other researchers argue for a multiple-indicator approach to attitude measurement (Cook & Selltiz, 1964), wherein an attitude is not measured directly, but is inferred from subjects' behavior.

Researchers have used a variety of techniques to assess attitudes toward mathematics, and a multitude of attitudinal investigations have been conducted in the last twenty years in the field of mathematics education. Those dealing with elementary school students' attitudes toward mathematics are reviewed in the next section.

Attitudes Toward Mathematics of Elementary School Students

A number of attempts have been made to establish the relationship between attitude toward mathematics and pupil achievement in mathematics. Studies by Poffenberger and Norton (1969) and by Shapiro (1962) found low positive correlations between the two criteria. The results of the extensive National Longitudinal Study of Mathematical Abilities (NLSMA) suggested a rather stable pattern of positive correlations of mathematics attitude scores with both mathematics achievement scales and mathematics grades in each of the populations of the study (Crosswhite, 1972). On the other hand, studies by Antonnen (1967), Cleveland (1961), and Faust (1963) failed to support the belief that there is a positive correlation between attitude and achievement in mathematics.

Some reseachers have tried to link general intelligence with attitude toward mathematics. In a study with fourth-, fifth-, and sixth-grade students, Shapiro (1962) found that students with higher IQ had more positive attitudes toward mathematics. The NLSMA data suggested small but significant positive relationships between attitude scores and the general intelligence measures used in the study (Crosswhite, 1972).

Some evidence exists to suggest that attitudes toward mathematics may be formed as early as the third grade (Fedon, 1958; Stright, 1960; Callahan, 1971), although these attitudes tend to be more positive than negative in elementary school (Stright, 1960). And, interestingly, there is also evidence of a decline from the third through the sixth grades in the percentage of students who express negative attitudes toward mathematics (Stright, 1960). Analyses of group means across grade levels in the NLSMA study indicated that student attitudes toward mathematics peaked near the beginning of the junior high grades (Crosswhite, 1972).

At the elementary school level, attitude toward mathematics and achievement in mathematics are related to a number of personality variables, such as good adjustment, high sense of personal worth, greater sense of responsibility, high social standards, motivation, high academic achievement, and freedom from withdrawal tendencies (Naylor & Gaudry, 1973; Neufeld, 1968; Swafford, 1970). In addition, children with positive attitudes toward mathematics tend to like detailed work, to view themselves as more persevering and self-confident (Aiken, 1972), and to be more "intuitive" than "sensing" in personality type (May, 1972).

In a discussion about the role of attitudes in learning mathematics Neale (1969) observed that, when attitude scores are used as predictors of achievement in mathematics, a low but significant positive correlation is usually found. Neale's claim is documented in research studies by Moore (1972), Evans (1972), and Mastantuono (1971) with students at the elementary school level.

Elementary Teachers and Attitudes Toward Mathematics

Many of the studies on attitudes toward mathematics conducted in recent years have involved prospective teachers. This is not surprising, since students in pre-service courses are a convenient group from which to draw research samples. However, the attitudes of this group are very important because of the potential influence on pupils in the elementary schools.

Dutton (1951) examined prospective teachers' attitudes toward arithmetic and discovered that an alarming outpouring of unfavorable feelings toward arithmetic was expressed by 74 per cent of the 211 students surveyed. In a later study (1962), he found that 38 per cent of prospective elementary teachers expressed dislike for arithmetic, and 38 per cent said they liked arithmetic fairly well, but not enthusiastically. Reys and Delon (1968) reported that approximately 40 per cent of 385 elementary education majors whom they surveyed had unfavorable attitudes toward arithmetic.

Fortunately, the pre-service mathematics content and methods courses for prospective elementary teachers seem to have a positive effect on the improvement of attitudes toward mathematics (White, 1965; Gee, 1966; Wickes, 1968; Reys & Delon, 1968).

An observation that is, perhaps, reasonable is that the attitudes of elementary teachers toward mathematics are typically less positive than those of secondary school mathematics teachers (Wilson et al., 1968). Brown (1962) found that experienced teachers had more positive attitudes toward arithmetic and possessed a better understanding of the subject than did less experienced teachers, although the differences in attitudes and understanding were not significant. Todd (1966) found that a state-wide inservice course produced significant changes in attitudes toward arithmetic and in arithmetic understanding for the teachers who completed the course. Stright (1960) concluded that a large percentage of elementary teachers really enjoy teaching arithmetic and attempt to make the subject interesting; but the teachers' age, educational training, and years of teaching experience apparently had little effect on attitude toward teaching the subject.

Teacher Atttitude as Related to Student Attitude and Achievement

There is a general feeling among educators that teacher attitude and effectiveness in a particular subject are salient determiners of student attitudes and performance in the subject. Several years ago, in a study that attempted to identify the factors determining attitudes toward mathematics, Poffenberger (1956) concluded that:

> The teachers who tend to affect students' attitudes and achievement positively have the following characteristics: a good knowledge of the subject matter, strong interest in the subject, the desire to have students understand the material, and good control of the class without being overly strict [p. 116].

Though he identified certain characteristics that might affect attitude toward mathematics, Poffenberger did not establish the relationship between the teacher influence and other factors that make up the learning environment of the student.

At a conference on needed research in mathematics education held at the University of Georiga in 1967, Lowry commented as follows:

> There are a number of research possibilities beyond those available, having to do with the effect of teacher preparation, attitudes, adaptability, manner of presentation, etc., on student achievement and motivations in mathematics. The teacher component is so important that considerable effort should be placed on the study of the influence of various teacher characteristics on all outcomes of the learning situation [p. 119].

A number of studies have been conducted dealing with the influence of teacher characteristics on outcomes of the learning situation. The relationship between teacher attitude and student achievement in mathematics has been verified more often than has the connection between teacher attitude and student attitude.

A study by Torrance et al. (1966) conducted with sixth through twelfth grade mathematics teachers resulted in the conclusion that teacher effectiveness had a positive effect on student attitudes toward teachers, methods, and overall school climate. In a study which dealt with the influences on student attitudes of teacher attitudes encountered during the preceding three years, Phillips (1973) found that type of teacher attitude for two of the past three years, especially most-recent teacher attitude, was significantly related to student attitude toward mathematics. On the other hand, studies by Caezza (1970), Van de Walle (1973), and Wess (1970) found no statistically significant relationships between teacher attitudes and either the attitudes or changes in attitudes of their students.

Sex Differences in Attitudes Toward Mathematics

Traditionally, mathematics has been viewed as an interest or occupation more suited to men than to women. Consequently, one might suspect that males would score higher than females on tests of achievement in mathematics and on scales of attitude toward mathematics. Several studies at the college level (see Aiken & Dreger, 1961; Dreger & Aiken, 1957; Hilton & Berglund, 1974) have found sex differences in both attitudes and achievement in mathematics favoring males over females. However, at the elementary school level, the results have not been quite so definitive.

Chase (1949) found that fifth-grade girls disliked arithmetic more than fifth-grade boys, and the reason for the dislike was that the subject was considered to be difficult, presumably too difficult. Several years later, in a study with third, fourth, and sixth graders, Stright (1960) concluded that girls liked arithmetic better than boys. In a study which included fourth- and sixth-grade students, Reese (1961) found that measures of attitudes and anxiety may be better predictors of the mathematics achievement of females than of males.

The NLSMA comparisons of boys' and girls' attitude profiles suggested that major observable differences were established by the early junior high school years. Though girls entered the study at grade 4 with somewhat more positive attitudes, their increase in attitude was less than for boys during the late elementary school years (Crosswhite, 1972).

In a study of attitudes toward arithmetic of students in the intermediate grades Shapiro (1962) found no significant differences between the attitudes of boys and girls. A similar finding was reported by Wozencraft (1963). Dutton (1968) also concluded that boys and girls who had studied "new math" were about equal in their liking for arithmetic.

The somewhat inconsistent findings noted above indicate that, at least in attitudinal studies conducted at the elementary school level, separate data analyses by sex should be performed. Additional research evidence is needed before any conclusive judgments can be made about sex differences in student attitudes toward mathematics at this level.

Student and Teacher Attitudes as Related to Curriculum Materials

As a result of the modern mathematics movement of the 1960's, a number of studies have been conducted which compare the attitudes of students in a modern program with those of students in a traditional program. The most numerous of these investigations have dealt with the School Mathematics Study Group (SMSG) materials. In general, these studies have found that the mean mathematics attitude scores of students taught with the SMSG materials are not significantly different from the scores of those students taught with the traditional curriculum materials (Phelps, 1965; Osborn, 1965; Woodall, 1967; Hungerman, 1967). In fact, Osborn (1965) found that the attitudes of SMSG students were more negative than those of students in the traditional curriculum.

Results similar to those noted in the preceding paragraph have been obtained in other investigations which have compared "modern" and "traditional" programs of instruction. For example, in a study with students using the University of Illinois Committee on School Mathematics (UICSM) materials, Demars (1972) found no more improvement in attitudes toward mathematics of those students who used the UICSM materials than of those using traditional curriculum materials.

An individualized approach to instruction in mathematics can have a more positive effect on attitudes that a traditional approach. In discussing an evaluation of the Individually

Prescribed Instruction (IPI) mathematics materials, Maguire (1971) makes such a conclusion.

Concluding Remarks

Because of the diverse findings of many of the attitudinal investigations noted above, generalizability of results is difficult. Therefore, researchers must continue to investigate the comparative learning effects of differing attitudinal variables. The next part of this chapter discusses the literature pertaining to attitudes toward problem solving.

Part III: Attitudes Toward Problem Solving

The studies reviewed in Parts I and II of this chapter point to the fact that investigations of mathematical problem solving and of attitudes toward mathematics are extensive in scope, diverse in nature, and often conflicting in results. Clearly, there is a need for more research into the nature of each of these variables.

Recommendations Related to Problem Solving Attitudes

Several years ago Brownell (1942) observed that favorable student attitudes toward problem solving are a desirable educational outcome, and he remarked that such attitudes can be developed. More recently, Polya (1965) has stressed the importance of favorable teacher attitudes in helping students acquire problem solving proficiency. In a publication by the Ontario Institute for Studies in Education (1971) the following observation is made:

> Granted that problem solving is both a desirable and an essential part of school mathematics, it seems a necessary prerequisite for successful development of problem solving skills that both teacher and student have positive attitudes to problems. Many teachers, particularly in the elementary school, have scant knowledge of mathematical content, and therefore feel far from confident in venturing beyond teaching the superficial exercise type of problem. Often they transmit this basic insecurity to their students [p. 35].

Thus, there seems to be some scholarly agreement on the importance of fostering the development of favorable attitudes toward problem solving, both on the part of the teacher and student.

Aiken (1970) has called for more intensive investigations into the nature of attitudes toward mathematics and has suggested that an individual's attitude toward one aspect of the discipline, such as problem solving, may be entirely different from his attitude toward another phase of the discipline, such as computation. Researchers, however, have tended to use single, global measures of attitude toward mathematics, rather than investigating attitude toward only one phase of the discipline.

The purpose of the next several sections of this chapter is to review the work of the few researchers who have investigated problem solving attitudes. Each of the studies described below has special relevance for some aspect of the present investigation.

A Problem Solving Attitude Scale for College Students

Carey (1958) worked with a college-age population in an attempt to answer five questions: (1) Can a scale be constructed which measures attitude toward problem solving? (2) Are there sex differences on such a scale? (3) Is problem solving attitude related to problem solving performance? (4) Will an attempt to change attitude be followed by a change in performance? and (5) Will women respond more favorably than men to an attempt to improve their attitudes? Though Carey was interested in general problem solving, rather than mathematical problem solving, her study is important because it represents a first attempt at the construction of a problem solving attitude scale. She did find that it is possible to construct a reliable instrument with Likert-type format to measure attitudes toward problem solving. The use of this scale enabled her to conclude that men and women do differ in attitudes toward problem solving, that problem solving performance is positively related to problem solving attitude, and that when women's attitude toward problem solving is modified in a more favorable direction, they make significant gains in problem solving performance.

A Brazilian Study of Problem Solving Attitudes

Lindgren et al. (1964) studied attitudes toward problem solving as a function of success in arithmetic in Brazilian elementary schools. A 24-item adaptation of the Carey (1958) scale was constructed and translated in Portuguese. An arithmetic achievement test, a general intelligence test, and a socio-economic scale also were administered to the sample population of fourth-grade students. Attitudes favorable to situations involving the solving of problems were found to be positively and significantly correlated with arithmetic achievement, although the correlations were rather low. Problem solving attitudes also were correlated positively, but not significantly, with marks in arithmetic. Positive and significant correlations were found among success in arithmetic, intelligence test scores, and socio-economic status. Problem solving attitudes of the students showed near-zero correlations with intelligence test scores and socio-economic status. Unfortunately, the Lindgren study did not correlate problem solving attitudes with student performance in problem solving. The positive correlations found between problem solving attitudes and arithmetic achievement lead to the conjecture that a strong correlation could exist between problem solving performance and problem solving attitude.

A Problem Solving Inventory for Children

Covington and Crutchfield (1965) have reported several studies with the General Problem Solving Program, an apparently successful program for teaching children to apply heuristic strategies to problems. Though the problems are not mathematical in nature, the strategies are appropriate to mathematical problem solving. Of particular interest is the work by Covington (1966) to devise instruments that assess problem solving competency among upper elementary school children. Specifically, this effort is directed toward the development of the Childhood Attitude Inventory for Problem Solving (CAPS). CAPS consists of two scales. Scale I contains 30 true-false items and is designed to indicate children's beliefs about the nature of the problem solving process and attitudes toward certain aspects of problem solving. Included are items dealing with such ideas as the child's conception of the innateness or unchangeability of one's problem solving ability, the desirability of suppressing rather than expressing novel ideas, and the wisdom of persisting in the face of a problem that others have failed to solve. Scale II, also consisting of 30 true-false items, assesses the child's degree of self-confidence in dealing with problem solving tasks; it reflects some of the typical sources of children's anxiety about thinking, including the fear of having one's ideas held up for ridicule (see Covington, 1966).

Though CAPS is not designed to assess attitudes toward mathematical problem solving, it does hold promise as a model for the design of similar instruments related to mathematical problem solving. The nature of the problem solving process is such that many of the requisite skills and processes needed for the solving of mathematics problems are the same as those needed for the solving of general problems, and vice versa.

Concluding Remarks to the Chapter

Sifting through the voluminous problem solving and attitudinal literature for definitive answers to questions about the nature of each variable and the relationships between them is a tedious and often frustrating task. The complex nature of the concepts confounds the problem. At best, the research evidence about each of the two variables is inconclusive, and research into relationships between the two variables is almost nonexistent. One fact is clear. Because of the complex nature of each variable, the simultaneous investigation of attitudes and problem solving must take into account several sources of potential variability. Otherwise, the generalizability of the research findings is severely limited.

This chapter has reviewed the related research literature in three areas: problem solving, attitudes, and attitudes toward problem solving. Chapter 3 discusses the design of the study reported in this paper.

Chapter 3

DESIGN OF THE STUDY

This investigation of the relationships between student and teacher mathematical problem solving attitudes and student mathematical problem solving performance fits into the framework of information-oriented research (Suppes, 1967; Scandura, 1967) or relational research (Romberg & DeVault, 1967). Such studies provide information and insight into the nature of specific relationships between curriculum variables, thus making it feasible to formulate tentative hypotheses capable of being tested in more rigorously designed experiments. This chapter discusses the design of the present investigation and begins with some background information regarding the idea for the study.

The Idea and Background for the Study

The design of this study evolved as the author worked closely with teachers and children participating in the pilot testing and field testing of the Developing Mathematical Processes (DMP) program (Romberg, Harvey, & Moser, 1974, 1975, 1976). The DMP program is based on psychological research into the ways children learn mathematics, and utilizes an activity-oriented, measurement approach to the teaching and learning of mathematics in grades K-6. The program is being developed at the University of Wisconsin Research and Development Center for Cognitive Learning and is designed for use in a system of Individually Guided Education (IGE) in a multiunit elementary school (see Klausmeier, Quilling, & Sorenson, 1971). However, DMP also can be used in any type of elementary school where the progress of each child as an individual is important.

The entire DMP program is built around a sequence of hierarchically-ordered objectives and a program of instruction that leads to mastery of those objectives. The K-6 instructional materials are organized into 90 units, called topics, and are subdivided into levels to approximate the following grade distributions:

Topics	Approximate Grade Levels
1-40	Primary (K-2)
41-65	Lower Intermediate (3-4)
66-90	Upper Intermediate (5-6)

Brief descriptions of the first 65 DMP topics are given in Appendix A.

The basic underlying theme of the DMP program is problem solving. Using various mathematical processes, such as describing, and classifying, comparing and ordering, joining and separating, grouping and partitioning, and validating, children solve a wide variety of types of problems. Several important problem solving techniques are used in DMP to prevent children from solving problems mechanically or jumping to false conclusions and to encourage them to adopt a "stop and think" attitude before solving. One of these techniques is the inclusion of problems that have no answer or many answers. Effective problem solving also is promoted in DMP through the use of open sentences and equivalent sentences; the children have many experiences in writing, transforming, and solving sentences. Once the children have solved a particular sentence, they validate the solution by putting it back into the context of the problem to be sure it is reasonable. The following quotation, taken from the DMP Resource Manual, Topics 41-65 (Romberg, Harvey, & Moser, 1975), emphasizes several of the key strategies used in the program:

> Although DMP emphasizes some broad problem solving strategies such as the use of the open sentence, stress is also placed on the children's ability to develop their own ways to solve problems. Just as there is frequently more than one "right" answer, there is frequently more than one "right" sentence or one "right" way to solve. Children's perceptions of problem situations may differ though they may be equally correct. They need to be allowed time for trial, time for error, and time to learn from their errors [p. 50].

The developers of the DMP program believe that exposing children to a wide variety of problems will lead to a willingness to tackle new problems, will produce confidence in children's ability to handle new problems, and will enhance their ability to apply problem solving techniques.

As observed in Chapter 1 of this paper, the author has been impressed by the manner in which DMP students attack problems and by the positive affect which both students and teachers seem to possess with regard to the DMP program. Consequently, this personal observation, reinforced by similar ones made be other DMP staff members, precipitated the design of a study to investigate the mathematical problem solving performance of children and the problem solving attitudes of both teachers and children. The next section of the chapter presents an outline of the overall design of the study.

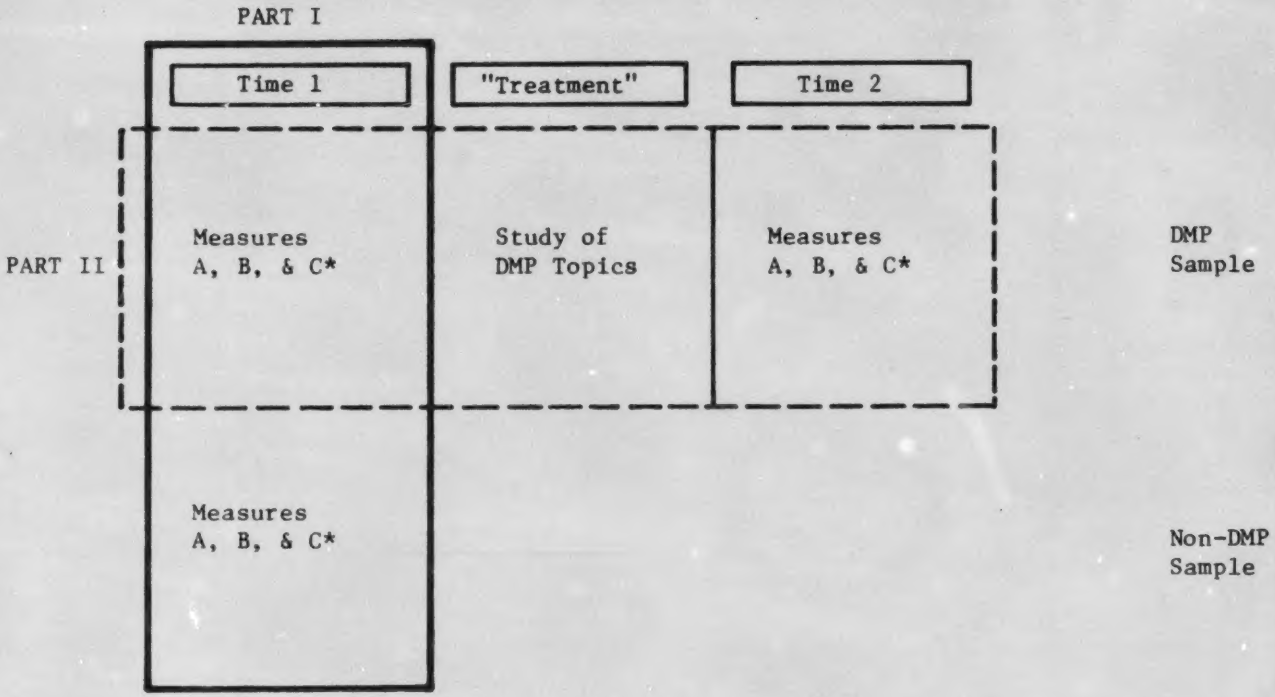
The General Design of the Study

The study was conceptualized as being conducted in two parts with samples from two different populations. The diagram in Figure 3.1 depicts the design. The specific details of each component of the design are delineated in ensuing sections of the chapter. The next section describes Part I of the study.

The Questions and Procedures for Part I

Part I of the study was to deal with the first five questions formulated in Chapter 1. They are:

Question 1: Do fourth-grade students have favorable attitudes toward problem solving?


PART I
Time 1
"Treatment"
Time 2
PART II
Measures A, B, & C*
Study of DMP Topics
Measures A, B, & C*
DMP Sample
Measures A, B, & C*
Non-DMP Sample

*Measure A: Student Mathematical Problem Solving Test
Measure B: Student Mathematical Problem Solving Attitude Scale
Measure C: Teacher Mathematical Problem Solving Attitude Scale

Figure 3.1. The design of the study.

Do differences in attitude toward problem solving exist if students are classified by sex?

Do differences in attitude toward problem solving exist if students are classified by mathematics program type. DMP versus non-DMP?

Question 2: Do fourth-grade teachers have favorable attitudes toward problem solving?

Do differences in attitude toward problem solving exist if teachers are classified by type of mathematics program taught: DMP versus non-DMP?

Question 3: How do fourth-grade students perform on a test of problem solving performance which provides measures of comprehension, application, and problem solving?

Do differences in problem solving performance exist when students are classified by sex?

Do differences in problem solving performance exist when students are classified by mathematics program type: DMP versus non-DMP?

Question 4: What is the relationship between fourth-grade students' attitudes toward problem solving and their performance in problem solving?

Do differences in this relationship exist if students are classified by sex?

Do differences in this relationship exist if students are classified by mathematics program type: DMP versus non-DMP?

Question 5: What is the relationship between fourth-grade teachers' attitudes toward problem solving and their students' performance in problem solving?

Do differences in this relationship exist if students are classified by sex?

Do differences in this relationship exist if students are classified by mathematics program type: DMP versus non-DMP?

The Sample

The subjects in the sample for Part I of the study were to be 30 fourth-grade teachers and the students to whom they taught mathematics. Fifteen of the teachers and their students were to have been participants in the large-scale field test (see Montgomery & Whitaker, 1975) of the Developing Mathematical Processes (DMP) program for at least one year prior to the 1975-76 school year. In addition, they were to be studying the commercial fourth-grade DMP materials during the 1975-76 school year. The remaining 15 teachers and their students were to be chosen from Wisconsin schools not using the DMP program. An attempt was to be made to involve teachers of both sexes and to obtain fourth-grade classes from schools varying in type (multiunit, non-multiunit), size, and location (urban, non-urban, rural).

The Procedures

During the fourth month of the 1975-76 school year, a mathematical problem solving test developed by Romberg and Wearne (see Wearne, in preparation) was to be administered to the students in the sample. At approximately the same time scales designed to measure the mathematical problem solving attitudes of both students and teachers were to be administered. The attitude scales were to be developed as a part of the study. The development of all three instruments used in the study is described in Chapter 4 of this paper. On the basis of their scores on the attitudinal instruments, the teachers and students were to be classified as having either favorable or unfavorable attitudes toward mathematical problem solving. The mathematical problem solving test data were to be categorized in terms of scores of comprehension, application, and problem solving and analyzed to ascertain the presence or absence of statistically significant differences with respect to sex of student and type of mathematics program studied (DMP versus non-DMP). Simple correlational procedures were to be used to show the relationships between teacher and student mathematical problem solving attitude and student mathematical problem solving performance. Correlations were to be calculated to show the relationships between the attitudinal and performance variables when the data were categorized by sex of student and program type (DMP versus non-DMP). It was anticipated that additional correlational procedures might be necessary to identify those items, or groups of items, from the attitudinal scales which might be interrelated with the calculated correlations. These findings were to provide information relative to Questions 1-5 of the study.

The Questions and Procedures for Part II of the Study

Part II of the study was to be directed at the remaining two questions posed in Chapter 1. They are:

> Question 6: Do fourth-grade teachers' attitudes toward problem solving affect their students' problem solving performance or is the effect of the opposite nature?

Do differences exist when students are classified by sex?

Question 7: Do fourth-grade teachers' attitudes toward problem solving affect their students' attitudes toward problem solving or is the effect of the opposite nature?

Do differences exist when students are classified by sex?

The Sample

The subjects in the sample for Part II were to be the 15 teachers and their students from the DMP sample of Part I. The non-DMP teachers and students were not to participate in the second part of the study.

The Procedures

Simple correlational procedures could not answer the questions of cause and effect posed for the second part of the study. However, Campbell and Stanley (1963) have discussed a quasi-experimental design which can provide answers regarding the direction of relationship between teacher attitude and student attitude and performance. The design employs time as a third variable and is called cross-lagged panel correlation (Campbell & Stanley, 1963). As indicated in Figure 3.1, Part II of the study was to involve the DMP sample and was to consist of two different testing periods (Time 1 and Time 2) with an intervening "treatment" period of 10-12 weeks. The first testing period has already been described. The second testing period was to occur during the seventh month of the 1975-76 school year and was to consist of a second administration of the mathematical problem solving test and the student and teacher mathematical problem solving attitude scales. This part of the design of the study is quasi-experimental in nature because the intervening "treatment" is not rigidly controlled. The "treatment" was to consist of a course of study selected from the regular DMP sequence of topics for fourth grade. The only restriction placed on the "treatment" was that teachers were to select at least one topic from the problem solving strand of the DMP program; the remaining two or three topics were to be selected from the other content strands (see Appendix A). Monitoring visits were to be made to the participating schools during the "treatment" period to be certain that the DMP topics were actually being taught as requested. Figure 3.2 depicts a schematic conception of the first phase of the cross-lagged correlational technique used in the study.

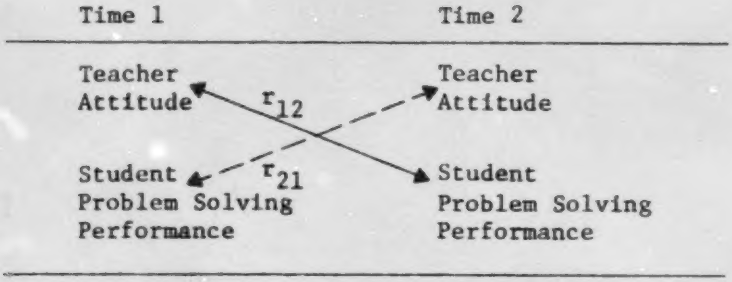

Time 1
Time 2
Teacher Attitude
Teacher Attitude
r_{12}
r_{21}
Student Problem Solving Performance
Student Problem Solving Performance

Figure 3.2. Schematic conception of cross-lagged panel correlation.

The correlation between teachers' attitudes at Time 1 and the means of the problem solving test scores of their students at Time 2 (r_{12}) were to be computed, as well as the correlation between teacher attitudes at Time 2 and the means of the problem solving test scores of their students at Time 1 (r_{21}). If r_{12} is significantly more positive than r_{21}, this would be evidence that teachers' initial attitudes have a greater effect on final mean student problem solving performance than initial mean student problem solving performance has on final teacher attitude. However, if r_{21} is significantly more positive than r_{12}, then this would provide an indication that initial mean student problem solving performance has a greater effect on final teacher attitudes than initial teacher attitudes have on final mean student problem solving performance. This type of correlational analysis for attitudinal research has been recommended by Aiken (1969).

A similar cross-lagged panel correlational analysis was to be used to study the effects of teacher attitudes toward problem solving on student attitudes toward problem solving. A schematic conception of this analysis is given in Figure 3.3.

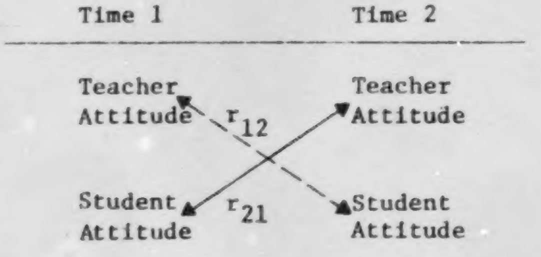


Figure 3.3. Schematic conception of cross-lagged panel correlation.

Concluding Remarks

This chapter has provided some background regarding the design of the study and has discussed the several components of the design. The next chapter describes the construction of the instruments which were used in the study.

Chapter 4

THE INSTRUMEMTS OF THE STUDY

Three instruments were used in the present study of the relationships between fourth-grade students' mathematical problem solving performance, their mathematical problem solving attitudes, and the mathematical problem solving attitudes of their teachers. The purpose of this chapter is to describe each of those instruments. The mathematical problem solving test was developed by Romberg and Wearne (see Wearne, in preparation); it will be described first. The other two instruments, the student mathematical problem solving attitude scale and the teacher mathematical problem solving attitude scale, were developed by the author; their development will be discussed in the last two sections of the chapter.

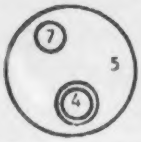
The Mathematical Problem Solving Test

Single total scores, as obtained on most tests of mathematical problem solving performance, are inadequate when attempting to explain the reasons why some students are successful problem solvers and others are not. However, a test developed by Romberg and Wearne (Wearne, in preparation) was designed to overcome such inadequacies and was used to assess the mathematical problem solving performance of the fourth-grade students in the present study.

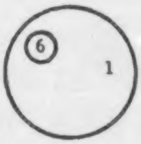
The mathematical problem solving test was designed to yield three scores: a comprehension score, an application score, and a problem solving score. Each of the 22 three-part items on the test contains a comprehension, an application, and a problem solving question. The comprehension question assesses a child's understanding of the information presented either explicitly or implicitly in the item stem. The application question involves a fairly straight forward application of some rule or concept to a situation. The problem solving question presents a situation which involves other than a routine application of some principle. Although the application and problem solving parts may refer to a common unit of information (the item stem), the questions are independent in that the response to the application question is not used to respond to the problem solving question. Because this test differs markedly from other mathematical problem solving tests, two examples of the three-part items on the test are given here to illustrate the nature of the comprehension, application, and problem solving parts. Figure 4.1 illustrates one three-part item from the test. In Figure 4.1 the item stem and the comprehension part are shown first; the comprehension part assesses a child's understanding of the information presented

THESE PROBLEMS ARE ABOUT HOW PEOPLE WRITE NUMBERS IN CIRCLELAND.

In Circleland, people write

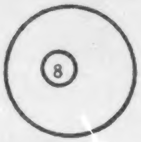


when they mean 475 and they write



when they mean 61.

In Circleland, people write



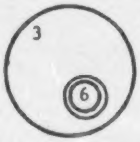
when they mean 8.

(A) True

(B) False

(C) Impossible

What do they mean when they write



?

(A) 36

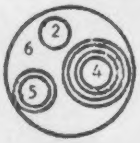
(B) 63

(C) 630

(D) 603

(E) 306

What do they mean when they write



?

(A) 4,526

(B) 40,526

(C) 4,562

(D) 45,620

(E) 45,260

Figure 4.1. Example of a three-part item from the mathematical problem solving test.

explicitly in the item stem. The second part of the item (application) is answered by direct application of information contained in the item stem, while the third part of the item (problem solving) requires a generalization of information presented in the item stem.

Figure 4.2 gives a second example of a three-part item from the mathematical problem solving test. In this example the item stem is given implicitly in the comprehension part of the item; it presents the information pictorially and assesses a child's comprehension of a "beam in balance." The second part of the item is a direct application of a balance beam to a situation which requires one to determine the order relation between two objects on the attribute of weight. The third part of the item represents an extended application of the second part; a child must realize that the sum of two smaller weights is less than the sum of two larger weights.

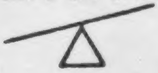
The mathematical problem solving test used in the present study is a revision of an earlier 19-item test developed by Romberg and Wearne and used in the study by Meyer (1975). The version used by Meyer with 179 fourth-grade students had undergone a careful development (see Meyer, 1975), and the total test Hoyt reliability coefficient for that test was .82.

The Romberg-Wearne Mathematical Problem Solving Test used in the present study is given in Appendix B; its development is described more completely by Wearne (in preparation). Because of the test's unique design, with three scores possible for each

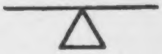
THESE PROBLEMS ARE ABOUT BALANCE BEAMS.

Which picture shows the balance beam in balance?

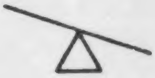
(A)

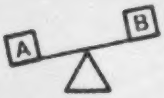


(B)



(C)





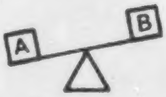
Which sentence tells about the weights $\boxed{A}$ and $\boxed{B}$?

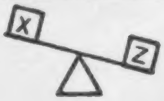
(A) $\boxed{A}$ weighs less than $\boxed{B}$.

(B) $\boxed{A}$ weighs more than $\boxed{B}$.

(C) $\boxed{A}$ weighs the same as $\boxed{B}$.

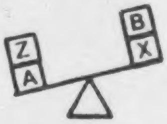
(D) Impossible to tell from the picture.



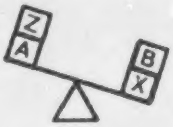


Weights $\boxed{A}$ and $\boxed{Z}$ are put together on one end of the balance beam and $\boxed{B}$ and $\boxed{X}$ are put together on the other end of the balance beam. Which picture shows how the balance beam might look?

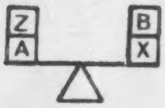
(A)



(C)



(B)



(D) Impossible to tell from the picture.

Figure 4.2. Example of a three-part item from the mathematical problem solving test.

student, it was deemed particularly appropriate for use in an investigation of mathematical problem solving attitudes, as student attitude may be examined in relation to a three-step sequence which students follow in solving a mathematics problem. The construction of the student mathematical problem solving attitude scale is described in the next section of this chapter.

The Student Mathematical Problem Solving Attitude Scale

Introduction

Though observational and interview techniques hold promise as perhaps the most objective measures of attitudes, the large number of students who were to be tested in the present investigation made such techniques impractical. Past efforts to develop scales that measure attitude toward problem solving have met with reasonable success. Carey (1958) found that a reliable scale can be constructed. A modification of the Carey scale was used by Lindgren et al. (1964) with a group of fourth-grade students in Brazil. Successful efforts have also been exerted by Covington (1966) to develop a group-administered inventory of problem solving attitude with upper elementary school children.

The Carey scale was deemed inappropriate for use in the present study, since it was developed for use with college-age students; furthermore, it assesses attitude toward problem solving in general, rather than attitude toward mathematical problem solving. The scale usde by Lindgren et al. might have proved useful in the present study, since it was given to fourth-grade students, but efforts by the author to obtain a copy of the scale proved futile. The inventory developed by Covington assesses general problem solving attitude, rather than mathematical problem solving attitude, and is limited in the amount of information conveyed regarding the intensity of the respondents' attitudes since the inventory uses a true-false format; thus, it, too, was rejected for potential use in the present investigation. The futility of the search for a suitable existing instrument to measure elementary school students' mathematical problem solving attitudes convinced the author of the need to develop such a scale.

The Construction of the Scale

In Chapter 1 attitude toward problem solving was defined as the predisposition of an individual to evaluate factors related to mathematical problem solving in a relatively favorable or unfavorable manner. The problem of constructing a scale to measure this attitude began with an examination of the attitudinal object--in this case, mathematical problem solving--and of those factors related to that object. Mathematical problem solving was defined as the process of analyzing a situation posed in a problem, producing a procedure for solving the problem, using that procedure, and achieving a solution to the problem. This definition is similar in nature to the four phases of the problem solving process suggested by Polya (1945), and both the definition and the writings of this eminent teacher proved valuable as sources of ideas for attitude scale items. In addition, the work by Carey and by Covington, and the writings of the staff of the Developing Mathematical Processes (DMP) program (see Romberg et al., 1974, 1975, 1976) guided the author's thinking in the development of the mathematical problem solving attitude scale.

Nunnally (1967) has remarked that if verbalized attitude is the variable of interest, then the content validity of the instrument to be constructed is the major issue; furthermore, he maintains that the major standards for ensuring content validity are a representative collection of items and a sensible method of instrument construction. Another aspect of content validity is that of face validity, that is, a judgment regarding whether an instrument appears to measure what it purports to measure. Both content validity and face validity were carefully considered in the design of the student mathematical problem solving attitude scale.

A procedure similar to that used in the development of the NLSMA attitude scales (see Romberg & Wilson, 1969) was followed by the author in the construction of the student attitude scale. First, a pool of 82 items was constructed; each item purportedly measured some aspect of fourth-grade students' attitudes toward mathematical problem solving. Included were statements reflecting children's beliefs about the nature of various types of mathematics problems, the nature of the problem solving process, the desirability of persevering when solving a problem, and the value of generating several ideas for solving a problem. Other statements referred to children's ability to succeed in problem solving situations, and some dealt with possible anxiety in not knowing how to go about solving a problem or the fear of being incapable of effective thought when attempting to solve a problem. An attempt was made to maintain a balance between positive and negative items. A complete listing of these 82 original items is included in Appendix C.

Next, the list of items was submitted to a panel of reviewers for careful scrutiny. The panel consisted of six mathematics educators, two experienced elementary school teachers, a licensed psychometrist, and two elementary mathematics curriculum writers. The reviewers were asked to examine the items with respect to adequacy of sampling of behaviors indicative of fourth-graders' attitude toward mathematical problem solving, to mark those items which they felt not indicative of such an attitude, and to indicate the direction--positive or negative--of those items which were indicative of the attitude. The reviewers also were encouraged to suggest changes in wording of the statements. The reading level of attitudinal instruments used with elementary school students often poses a problem of reliability and interpretability of results of those instruments (Aiken, 1969). For that reason, an experienced fourth-grade teacher was asked to examine the problem solving attitude item sample solely on the basis of readability by fourth-grade students. Any item that was rejected by at least two reviewers was discarded as inappropriate for inclusion in the instrument.

It was the author's desire to make the format of the student attitude scale as appealing as possible to fourth-grade students and to avoid the use of "adult" terminology. For this reason, the typical response format of Likert scales--strongly agree, agree, undecided, disagree, strongly disagree--was changed to that of really agree, agree, can't decide, disagree, really disagree. In addition, one reviewer suggested that some of the attitudinal items might lend themselves to a "happy/sad faces" format. Consequently, the author decided to organize the pilot scale in two parts. The first part consisted of those items which could be written as open-ended statements and to which students could respond using a "very happy-to-very sad faces" format. An example of such an item is given in Figure 4.3.

If we spent more time in school doing math problems,

I would be

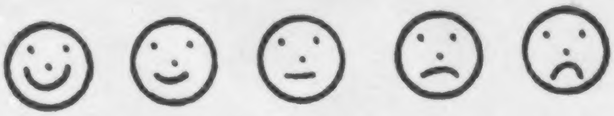


Figure 4.3. Example of a mathematical problem solving attitude item with "happy/sad faces" format.

The first part of the pilot scale consisted of 14 such statements and was designed to provide an "informal" measure of each student's attitude toward mathematical problem solving.

The second part of the pilot attitude scale consisted of 26 items to which the students were to respond using the "really agree-to-really disagree" format. An example of one of these items is in Figure 4.4.

After I read a problem, I like to think about what I know and what I don't know in the problem.

_____ REALLY AGREE

_____ AGREE

_____ CAN'T DECIDE

_____ DISAGREE

_____ REALLY DISAGREE

Figure 4.4. Example of a mathematical problem solving attitude item with modified Likert format.

This part of the scale was designed to provide a more "formal" measure of each student's attitude toward mathematical problem solving. The specific nature of many of the items allowed for a probe into the more subtle ramifications of a student's attitude.

Using the developmental sequence described above, a 40-item pilot scale was constructed to measure fourth-grade students' attitudes toward mathematical problem solving. A copy of this scale is included in Appendix C. The 14 "informal" items were randomly ordered to form Part I of the scale. The 26 "formal" items were randomly ordered to form Part II of the scale. To provide some control for those students who might unconsciously compare one item with another, only four or five items were included on each page of the scale.

The Pilot Test

The pilot version of the student mathematical problem solving attitude scale was administered by the author to 51 fourth-grade students in two elementary schools in Madison, Wisconsin. Test administration time was approximately 20 minutes. The written directions for the scale were judged to be satisfactory, and no problems were observed with the administration of the scale or with student response to the scale.

The Item Analysis

The item responses of each student were coded on a five-point scale, ranging from a score of 5 for the most favorable response to 1 for the most unfavorable response. A total scale score of 200 represented the "most favorable" attitude toward problem solving, a total score of 120 signified a "neutral" attitude, and a total score of 40 represented the "most unfavorable" attitude; varying degrees of "favorableness" or "unfavorableness" were represented by intermediate scores. Mean total score response was 142.9.

An item analysis was performed on Part I, Part II, and the total scale by using the ITEMPACK program (Campbell & Bohrnstedt) at the University of Wisconsin Academic Computing Center. The ITEMPACK program is specially designed for use with Likert scales. Cronbach's Alpha (Cronbach, 1951), a measure of the internal consistency reliability of an instrument, was computed for each part of the scale, and these are given in Table 4.1.

TABLE 4.1

INTERNAL CONSISTENCY RELIABILITIES
FOR PILOT ATTITUDE SCALE (N = 51)

Scale	Number of Items	Cronbach's Alapha	Standard Error of Measurement
Part I	14	.84	3.32
Part II	26	.86	5.36
Total	40	.90	6.41

The reliability coefficients were judged to be quite satisfactory for each part of the scale and for the total scale. As an additional means of analyzing the internal consistency of an instrument, the ITEMPACK program uses algorithms suggested by Bohrnstedt (1969) to correlate each item score with the total scale score. The program also calculates corrected item-to-total correlations using the procedure suggested by Cureton (1966);

this calculation corrects for the spurious result caused by the inclusion of the item in each correlation. The Cureton item-to-total correlations for the student scale are given in Appendix C. The correlations were judged to be acceptable for nearly all items. For items 7, 13, and 34 the item-to-total correlations were negative; therefore, these items were eliminated from the scale. For items 9, 17, 19, 22, and 24 a weak positive relationship was noted. Item 9 was dropped from the scale; however, because of the importance of the content of the other items to the attitude being assessed, it was felt that they should remain in the scale.

The Revised Scale

As a result of the pilot test of the student mathematical problem solving attitude scale and the subsequent item analysis, a revised 36-item scale emerged. The revised scale consists of two parts. Part I has 12 items designed to provide an "informal" measure of a student's attitude toward mathematical problem solving. Part II consists of 24 items designed to provide a "formal" and more specific measure of the attitude. The total scale, then, provides a composite measure of a number of variables which influence a fourth-grade student's attitude toward mathematical problem solving. A copy of the revised scale is given in Appendix D.

Concluding Remarks

This section of the chapter has described the developmental sequence followed in the construction of a mathematical problem solving attitude scale for elementary school students. The next section discusses the development of a similar scale for use with elementary school teachers.

The Teacher Mathematical Problem Solving Attitude Scale

The only existing scale for assessing adult attitudes toward problem solving (Carey, 1958) was judged inappropriate for use with the teachers who were to participate in the present study, mainly because it measures general problem solving attitude, rather than attitude toward mathematical problem solving. Therefore, the author concluded that a scale suitable for use with elementary school teachers would have to be constructed as a part of the study.

The Construction of the Scale

The Likert method of summated ratings also was selected as the format for the teacher mathematical problem solving attitude scale. A developmental sequence nearly identical to that described previously for the student attitude scale was adopted for the construction of the teacher scale. First, a pool of 70 items was written; each item purportedly measured some aspect of an elementary teacher's attitude toward mathematical problem solving. The pool of student items served as a valuable source of ideas for writing the teacher items. Many of the statements were, in fact, similar in content and wording to those written for the student scale. A complete list of the original 70 items is given in Appendix C.

Next, the list of items was submitted to the same panel of reviewers who examined the student items, and they were asked to react to the new set of items in a manner similar to that used with the student items. Once again, any item that was rejected by at least two reviewers was discarded.

The five-part response format--really agree, agree, can't decide, disagree, and really disagree--was used on the teacher scale. The developmental sequence noted above yielded a 50-item pilot scale. A copy of that scale is given in Appendix C.

The Pilot Test

A pilot version of the teacher mathematical problem solving attitude scale was administered by the author to 28 elementary school teachers. Eighteen of the teachers were enrolled in graduate courses in the Department of Curriculum and Instruction at the University of Wisconsin-Madison. The remaining 10 teachers were members of the faculty at an elementary school in Madison, Wisconsin. Test administration time was approximately 20 minutes, and no problems were observed with the directions given or with teacher response to the scale. After the scales had been collected, the teachers were encouraged to discuss their reactions to the scale with the author. Several teachers commented on the similarity of content of some items; others noted that the "really agree-to-really disgree" response format did not seem appropriate for several of the items.

The Item Analysis

A five-point coding scheme was adopted for coding each response on the teacher scale so that the maximum possible score was 250, indicative of a "very favorable" attitude toward mathematical problem solving. A score of 150 indicated a "neutral" attitude, while a score of 50 meant a "very unfavorable" attitude; varying degrees of "favorableness" or "unfavorableness" were represented by intermediate scores. Mean total score response for the pilot sample was 181.5.

The ITEMPACK program (Campbell & Bohrnstedt) at the University of Wisconsin Academic Computing Center was utilized once again, and an item analysis was performed on the scale. The internal consistency reliability (Cronbach, 1951) of the teacher scale was found to be .96, with standard error of measurement of 5.71. This high level of internal consistency reliability was not surprising, as many statements were merely negations of others. The Cureton (1966) corrected item-to-total correlations for individual items on the scale indicated that items 25, 28, 31, and 44 had very low positive correlations; they were eliminated from the scale. A close examination of the remaining 46 items showed that many were similar in content. Furthermore, several were closely related to a category which might be termed "reactions to the teaching of problem solving." Therefore, the author decided to do a more extensive revision of the teacher scale than had been undertaken with the student scale. A set of 15 additional items was written; these items were designed to assess teachers' reactions to those activities related to the teaching of various problem solving skills and processes. The items were submitted to the panel of reviewers for their examination. In addition, it was decided to use a second response format--always, usually, sometimes, seldom, never--with some items on the scale.

The Revised Teacher Scale

The developmental sequence outlined above resulted in a revised 40-item teacher mathematical problem solving attitude scale. A copy of the scale is included in Appendix D. Thirty-one of the pilot scale items were used. Nine items were included which dealt with the teaching of problem solving skills and processes. The total scale is designed to provide a composite measure of several variables which reflect an elementary school teacher's attitude toward mathematical problem solving.

Concluding Remarks

This chapter has described the three instruments used in the present study. The mathematical problem solving test was developed by Romberg and Wearne (Wearne, in preparation). The student and teacher mathematical problem solving attitude scales were constructed by the author, and their development has been described in some detail. With the availability of instruments designed to measure the three main variables of interest in the study, the questions of the study could then be investigated. The next chapter discusses the conduct of the study.

Chapter 5

THE CONDUCT OF THE STUDY

The design of this study of the relationships between certain noncognitive factors and the mathematical problem solving performance of fourth-grade children was reported in Chapter 3, and the development of the three instruments used in the study was discussed in the last chapter. The study was conducted according to the plans as described in Chapter 3. However, because the study was conducted in schools, not in a laboratory setting, certain modifications in the original plans were necessitated. The purpose of this chapter is to describe the details of the conduct of the study and to delineate the modifications in plans which were necessary. As noted in Chapter 3 and illustrated in Figure 3.1, the study was conducted in two parts with two different samples. The conduct of Part I is discussed first.

Part I of the Study

Chapters 1 and 3 described Questions 1-5 of this study. Part I was designed to answer those questions. The sample and the details of the procedures for this part of the study are described below.

The Sample

The subjects in the sample for Part I of the study were 30 fourth-grade teachers and their fourth-grade mathematics classes. Fifteen of the teachers and their students were participants in the large-scale field test of the Developing Mathematical Processes (DMP) program for at least one year prior to the 1975-76 school year. In addition, they were using the commercial fourth-grade DMP materials during the 1975-76 school year. The 15 DMP teachers and their mathematics classes were in six schools in two different school districts in southern Wisconsin. The remaining 15 fourth-grade teachers and their students who participated in Part I of the study were in seven schools in two different school districts in southern Wisconsin. These teachers and students were not using the DMP program, but were using commercially available mathematics textbook series. Some of the characteristics of the sample are summarized in Table 5.1. In that table, Schools 1-6 represent the DMP sample, while Schools 7-13 represent the non-DMP. sample.

All of the students participating in the study were enrolled in fourth-grade mathematics classes. Their teachers were certificated elementary teachers with varied educational training and teaching experience. Each teacher held at least a bachelor's degree, and seven had earned master's degrees. Years of teaching experience ranged from 2 to 35; mean number of years taught was 11.8.

TABLE 5.1

CHARACTERISTICS OF THE SAMPLE FOR THE STUDY

School No.	Multiunit	Enrollment	Grades Enrolled	No. of Classes Participating	School Setting
1	no	585	K-6	3	suburban
2	no	354	K-6	2	suburban
3	yes	417	K-6	2	suburban
4	yes	251	K-6	2	suburban
5	no	370	3-5	4	suburban
6	no	382	K-5	2	rural
7	no	206	K-7	1	suburban
8	yes	697	K-6	4	suburban
9	yes	535	K-6	3	suburban
10	yes	159	K-6	1	rural
11	yes	611	K-6	4	suburban
12	yes	160	K-6	1	rural
13	yes	177	K-6	1	rural

The Procedures

During the second week of December, 1975, the three instruments of the study were administered to the DMP students and teachers participating in Part I of the study. All tests were administered by the author or by a testing specialist from the University of Wisconsin Research and Development Center. The testing was carried out in the classrooms of the participating schools on two different days.

The mathematical problem solving test was administered on the first day. Each group of students was given 45 minutes to respond to the 22 three-part items on the test; some students were unable to complete all the items in the time allotted. Two days later the mathematical problem solving attitude scale was administered to the students; administration time was 20 minutes. While students responded to the attitude scale, their teachers responded to the teacher mathematical problem solving attitude scale; response time for teachers was appoximately 15 minutes. Both students and teachers were given sufficient time to respond to all items on the attitude scales.

The author had hoped to conduct the non-DMP testing immediately following that done with the DMP sample. However, the DMP testing was completed about one week prior to the start of the Christmas holiday period for the schools in southern Wisconsin. Consequently, the author and the principals of the participating non-DMP schools decided to delay the testing with those students and teachers until after the holiday period. The resumption of the testing schedule immediately after the holiday period also was judged unwise. Therefore, the non-DMP testing was begun during the second week of January, 1976. The same procedures were followed with the non-DMP sample as were used with the DMP sample. The mathematical problem solving test was given on the first of two testing days in each school. In four of the schools, the mathematical problem solving attitude scales were administered two days later. However, because of scheduling difficulties in three schools, the attitude scales could not be given until four days later. The testing of non-DMP students and teachers was completed early in the fourth week of January. The time difference in testing of the DMP and non-DMP groups was noted, but was not considered serious, since the periods immediately prior to and immediately following a long holiday vacation typically are not regarded as effective instructional periods.

As noted previously the study was designed to be conducted in two parts. This section has described Part I. The next section describes Part II.

Part II of the Study

The second part of the study was directed at Questions 6 and 7 as posed in Chapters 1 and 3. Ensuing paragraphs of this section describe the sample and the procedures for this part of the study.

The Sample

The subjects in the sample for Part II were to be the 15 fourth-grade teachers and their mathematics students from the DMP sample of Part I. Unfortunately, in the duration between the first and second testing periods, one of the participating teachers resigned. Therefore, the second part of the study was conducted with 14 teachers and their students, instead of 15, as originally planned. The non-DMP teachers and students did not participate in the second part of the study.

The Procedures

As described in Chapter 3, the second part of the study involved two different testing periods (Time 1 and Time 2) with an intervening "treatment" period. The first testing period has been described previously. The second testing period commenced during the second week of March, 1976. Scheduling difficulties and an intervening school vacation period prohibited the completion of the second round of testing before the last week of March, 1976.

The testing at Time 2 was conducted in the classrooms of the participating schools and occurred on two different school days. Tests were administered by the author and the testing specialist who had assisted with the testing at Time 1. The mathematical problem solving test was administered on the first day; this test was an alternate version of that used at Time 1. The basic design of the test was identical to that used earlier; however, each of the 22 items on the second version had a multiple-choice format. A copy of this second problem solving test is given in Appendix B. Administration time for the mathematical problem solving test was 45 minutes, and some students were unable to complete the test in the time allotted.

The mathematical problem solving attitude scales were administered to the students and teachers one day after the administration of the mathematical problem solving test. Scheduling difficulties hindered the allowance of two days between testing times as had been done at Time 1; this slight variation in testing times was not considered serious. The second problem solving attitude scales contained items identical to those used at Time 1; however, for this administration, the items on each scale had been re-randomized. Copies of the second student and teacher mathematical problem solving attitude scales are given in Appendix D. Administration times were 20 minutes for the student attitude scale and 15 minutes for the teacher scale. Subjects had ample time to respond to all items.

The intervening "treatment" period between Time 1 and Time 2 lasted approximately 12 weeks. The duration could not be controlled precisely because of the difficulties associated with scheduling convenient testing times for 14 classes in six different schools in two different school districts. The "treatment" itself consisted of a course of study selected from the regular DMP sequence of topics for fourth grade. The only restriction placed on the "treatment" was that teachers were to select at least one topic from the problem solving strand of the DMP program; the remaining topics were selected from the other content strands (see Appendix A).

Prior to the testing at Time 1 all classes had covered the DMP topics through Topic 52, Investigating Problems; all but two classes had covered two additional topics notably Topics 53 and 54. Without exception, the topic from the DMP problem solving strand which teachers elected to cover during the "treatment" period was Topic 57, The Numbers 0-999,999. The number of additional topics completed during the "treatment" period ranged from two topics in two of the classes to five topics in five of the classes. Mean number of topics completed was 3.7. All but two classes completed Topic 55, Representing Common Fractions.

Monitoring visits were made to four of the participating schools during the "treatment" period to be certain that the DMP topics were actually being taught as requested. These visits were made by a mathematics learning specialist in that school district. This person was a trained DMP Coordinator (see Montgomery & Whitaker, 1975) and was knowledgeable of both DMP content and DMP methodology. Monitoring visits to the remaining two schools were deemed unnecessary as the author had worked closely with the teachers in those schools during the preceding school year and was confident of the teachers' ability to teach the DMP topics as requested.

Concluding Remarks

This chapter has summarized the conduct of the study. Because the setting for the study was in schools and not in a laboratory, some changes in the original plans were mandated. However, these changes were not major, and the basic design of the study was unaltered from the time of its conception through its conduct. The data gathered according to the details described in this chapter were analyzed according to plans described in Chapter 3. The next chapter discusses the analysis and interpretation of the data.

Chapter 6

ANALYSIS AND INTERPRETATION OF THE DATA

Previous chapters of this paper have described the details of the present investigation up to and including the conduct of the study. The purpose of this chapter is to discuss the analysis and interpretation of the data gathered according to the procedures described in Chapter 5. As noted earlier, the study was conducted in two parts. To facilitate the discussion, this chapter also is organized in two parts and begins with the analysis and interpretation of the data which were gathered to answer the questions of Part I of the study.

Analysis and Interpretation of the Data for Part I

Five main questions served as the foci around which the first part of the study was conducted and the data were analyzed. Each of those questions and its related ancillary questions are repeated here; following each is a presentation and discussion of the data pertaining to that question.

Data for Question 1

The first question of the study was: Do fourth-grade students have favorable attitudes toward problem solving? In order to answer this question, a mathematical problem solving attitude scale was administered to students in 30 fourth-grade mathematics classes in 13 Wisconsin schools.

The student mathematical problem solving attitude scale consists of 36 items with Likert format. The scale has two parts. Part I has 12 items designed to provide an "informal" measure of attitude. Part II consists of 24 items designed to provide a "formal" and more specific measure of the attitude. The total scale, then, provides a composite measure of a number of variables which influence a fourth-grade student's attitude toward mathematical problem solving. A copy of the scale is included in Appendix D.

For scoring the student mathematical problem solving attitude scale, item responses of each student are coded on a five-point scale ranging from a score of 5 for the most favorable response to 1 for the most unfavorable response. Table 6.1 summarizes the scoring for each part of the scale and the total scale. A total scale score of 180 represents the most favorable attitude toward problem solving, a score of 108 signifies a neutral attitude, and a score of 36 represents the most unfavorable attitude; varying degrees of favorableness or unfavorableness are represented by intermediate scores. As a measure of students' reactions to general types of mathematics problems, Part I of the scale allows scores ranging from 60 for most favorable to 12 for most unfavorable, with a score of 36 representing a neutral attitude. Part II of the scale assesses students' reactions to specific problem situations

TABLE 6.1

SCORING FOR THE STUDENT MATHEMATICAL PROBLEM SOLVING ATTITUDE SCALE

Nature of Attitude	Part I Score	Part II Score	Total Score
Most Unfavorable	12	24	36
Unfavorable	24	48	72
Neutral	36	72	108
Favorable	48	96	144
Most Favorable	60	120	180

and problem solving techniques and permits scores ranging from 120 for most favorable to 24 for most unfavorable, with a score of 72 indicating a neutral attitude.

Table 6.2 gives a summary of the mathematical problem solving attitude scores for the 619 students who responded to the scale. As indicated in the table, the attitude scores of the fourth-grade students in the sample ranged from unfavorable to very favorable on each of the two parts of the scale and on the total scale. A comparison of the reported mean scores with the scoring summary in Table 6.1 indicates that each mean score lies in the interval between a neutral attitude toward mathematical problem solving and a favorable attitude toward mathematical

TABLE 6.2

MATHEMATICAL PROBLEM SOLVING ATTITUDE SCORES
OF STUDENTS IN SAMPLE POPULATION (N = 619)

Scale Part	Minimum	Maximum	Mean	St. Dev.
I (Informal)	12.0	60.0	43.7	8.4
II (Formal)	38.0	116.0	85.9	12.9
Total (Composite)	52.0	176.0	129.6	18.9

problem solving. However, each mean score is closer to that indicating a favorable attitude than to that indicating a neutral attitude. Thus, the fourth-grade students in the sample seemed to possess favorable attitudes toward mathematical problem solving as reflected by the scores on the attitude scale used in the study.

Following the administration of the student mathematical problem solving attitude scale an item analysis was performed on Part I, Part II, and the total scale by using the ITEMPACK Program (Campbell & Bohrnstedt) at the University of Wisconsin Academic Computing Center. Cronbach's Alpha (Cronbach, 1951), a measure of the internal consistency reliability of an instrument, was computed for each part of the scale. For Part I, the reliability coefficient was .85; for Part II it was .82; the total scale reliability coefficient was .88. These reliability estimates were judged to be quite satisfactory. Complete results of the item analysis, including the Cureton (1966) item-to-total correlations, are given in Appendix E.

Nunnally (1967) has observed that, for instruments which assess verbalized attitude, content validity is the major issue; furthermore, he maintains that content validity may be inferred if an instrument is developed using a representative collection of items and if a sensible method of construction is followed. Both of these criteria were met for the student mathematical problem solving attitude scale; the careful development of the scale was described in detail in Chapter 4. Another type of validity is face validity, that is, a judgment regarding whether an instrument appears to measure what it purports to measure (Sax, 1974). The face validity of the student scale was assured as a result of the review by a panel of judges as described in Chapter 4. Other forms of validity, such as concurrent or construct validity are best established through repeated use of the instrument in conjunction with other instruments designed to measure the same or similar traits.

One of the two ancillary queries related to Question 1 of the study was the following: Do differences in attitude toward problem solving exist if students are classified by sex? The second ancillary query was: Do differences in attitude toward problem solving exist if students are classified by mathematics program type: DMP versus non-DMP? In an effort to answer these questions, sex-by-program type analyses of variance were performed on the student attitudinal data. Tables 6.3 through 6.7 summarize the results of the analyses of variance. Table 6.3 shows the problem solving attitude scores of students categorized by sex, and the scores categorized by program type are given in Table 6.4, The ANOVAs for Part I, Part II, and Total attitude scores are shown in Tables 6.5, 6.6, and 6.7, respectively. As indicated in Table 6.3, mean attitude score for boys was slightly higher than that for girls on Part I of the scale, while for Part II, the girls' mean score was slightly higher than that of the boys. On the total scale, the mean total score for girls was again slightly higher than that of the boys, although boys had higher minimum and maximum scores than did the girls. According to the ANOVAs in Tables 6.5, 6.6, and 6.7, none of the indicated differences was significant at the .05 level.

As noted previously in this paper, 15 of the 30 classes in the study were using the Developing Mathematical Processes (DMP) curriculum materials; the remaining 15 were not. Table 6.4 shows that when the mathematical problem solving attitude scores of students were categorized by program type, the mean scores of the non-DMP sample were slightly higher than those of the DMP sample for each of the two parts of the scale and for the total

TABLE 6.3

MATHEMATICAL PROBLEM SOLVING ATTITUDE SCORES OF STUDENTS CATEGORIZED BY SEX (N = 619)

Scale Part	Boys (N = 334)			Girls (N = 285)		
	Min./Max.	Mean	S. D.	Min/Max	Mean	S. D.
I (Informal)	12/60	44.0	8.5	14/60	43.4	8.3
II (Formal)	42/116	85.4	12.6	38/116	86.5	13.1
Total	58/176	129.4	18.6	52/172	129.9	19.2

TABLE 6.4

MATHEMATICAL PROBLEM SOLVING ATTITUDE SCORES OF STUDENTS CATEGORIZED BY PROGRAM TYPE: DMP VERSUS NON-DMP (N = 619)

Scale Part	DMP (N = 324)			non-DMP (N = 295)		
	Min./Max.	Mean	S. D.	Min./Max.	Mean	S. D.
I (Informal)	19/60	43.0	7.9	12/60	44.5*	8.8
II (Formal)	45/116	85.7	12.6	38/114	86.2	13.2
Total	69/176	128.6	18.9	52/172	130.7	19.2

*significant at $p < .05$

TABLE 6.5

ANOVA FOR PART I ATTITUDE

Source	df	MS	F	p <
Sex	1	29.19	.42	.5174
Program Type	1	411.33	5.91	.0153
Sex X Program Type	1	445.47	6.40	.0117
Error	615	69.59		

TABLE 6.6

ANOVA FOR PART II ATTITUDE

Source	df	MS	F	p <
Sex	1	220.79	1.34	.2483
Program Type	1	76.96	.47	.4953
Sex X Program Type	1	462.16	2.80	.0950
Error	615	165.33		

TABLE 6.7

ANOVA FOR TOTAL ATTITUDE

Source	df	MS	F	p <
Sex	1	89.41	.25	.6152
Program Type	1	844.13	2.39	.1228
Sex X Program Type	1	1815.11	5.13	.0238
Error	615	353.57		

scale. As indicated by the ANOVAs in Tables 6.5., 6.6, and 6.7, the differences in mean response were significant at $p < .05$ only for Part I of the scale. Because of the small size of the differences in mean scores, it would seem that little practical significance should be attached to these differences.

Table 6.8 presents the mathematical problem solving attitude scores of students categorized by sex within program type. Mean response of non-DMP girls was consistently higher than that of the other three groups on each of the three scores. In the DMP sample, the mean response of boys was higher than that of girls on each of the three scores. As might be suspected from the ANOVAs in Tables 6.5 and 6.7, there was a significant ($p < .05$)

TABLE 6.8

MATHEMATICAL PROBLEM SOLVING ATTITUDE SCORES OF STUDENTS CATEGORIZED BY SEX WITHIN PROGRAM TYPE

Scale Part	DMP		non-DMP	
	Boys (N=170)	Girls (N=154)	Boys (N=164)	Girls (N=131)
I (Informal)				
Mean	44.0	41.9	44.0	45.2
S.D.	7.8	7.9	9.2	8.3
II (Formal)				
Mean	85.9	85.4	84.9	87.8
S.D.	12.1	13.2	13.2	13.0
Total				
Mean	129.9	127.2	128.8	133.0
S.D.	17.9	19.2	19.3	18.9

sex-by-program type interaction for Part I and the Total scale scores; a similar interaction can be noted for the Part II scores, although this interaction would be significant only if the significance level were lowered to .10 (see Table 6.6.). Though interesting, these interactions probably have little practical significance except to indicate that the two samples were, in some way, different; the differences may result from the samples not having been randomly chosen.

Data for Question 2

The second question of the study was the following: Do fourth-grade teachers have favorable attitudes toward problem solving? In an attempt to answer this question, a teacher mathematical problem solving attitude scale was administered to the teachers of the 30 fourth-grade mathematics classes involved in the first part of the study.

The teacher mathematical problem solving attitude scale consists of 40 items with Likert format. Thirty-one of the items assess teachers' reactions to types of mathematics problems, problem situations, and frustration or anxiety experienced when solving problems. The remaining items assess teachers' feelings with respect to the teaching of various problem solving skills and processes. The total scale is designed to provide a composite measure of several variables which reflect an elementary school teacher's attitude toward mathematical problem solving.

The scoring of the teacher scale is similar to that of the student attitude scale. Item responses are coded on a five-point scale, ranging from a score of 5 for the most favorable response to 1 for the most unfavorable response. Table 6.9 presents a summary of the scoring for the teacher attitude scale. A total scale score of 200 represents the most favorable attitude toward problem solving, a score of 120 signifies a neutral attitude, and a score of 40 indicates the most unfavorable attitude. Varying

TABLE 6.9

SCORING FOR THE TEACHER MATHEMATICAL PROBLEM SOLVING ATTITUDE SCALE

Nature of Attitude	Score
Most Unfavorable	40
Unfavorable	80
Neutral	120
Favorable	160
Most Favorable	200

degrees of favorableness or unfavorableness are represented by intermediate scores.

Table 6.10 presents information about the mathematical problem solving attitude scores of the 30 teachers involved in Part I of the study. The attitude scores of these fourth-grade teachers ranged from what might be termed "slightly" favorable to "very" favorable, as evidenced by the minimum score of 134 and the maximum recorded score of 175. The mean score for the sample indicates that these teachers did possess favorable attitudes toward mathematical problem solving as measured by the teacher scale used in the study.

TABLE 6.10

MATHEMATICAL PROBLEM SOLVING ATTITUDE SCORES OF TEACHERS IN SAMPLE (N = 30)

Min./Max.	Mean	St. Dev.
134/175	156.5	9.6

An ancillary question related to Question 2 was the following: Do differences in attitude toward problem solving exist if teachers are classified by type of mathematics program taught: DMP versus non-DMP? The results of categorizing the problem solving attitude scores of the teachers in the sample by program type are shown in Table 6.11.

TABLE 6.11

MATHEMATICAL PROBLEM SOLVING ATTITUDE SCORES OF TEACHERS CATEGORIZED BY TYPE OF PROGRAM TAUGHT: DMP VERSUS NON-DMP

Program Type	Min./Max.	Mean	St. Dev.
DMP (N = 15)	141/175	158.9	9.4
Non-DMP (N = 15)	134/165	154.1	9.6

The data reported in this table indicate that, though both groups of teachers had favorable attitudes toward problem solving, the attitudes of the DMP teachers were slightly more favorable than those of the non-DMP teachers. However, it is obvious from the data in Table 6.11 that the difference in mean scores is not significant.

The ITEMPACK program (Campbell & Bohrnstedt) was used to perform an item analysis on the teacher mathematical problem solving attitude scale after its administration. The internal consistency reliability (Cronbach, 1951) of the scale was found to be .80. Though the reliability estimate was somewhat lower than anticipated, it was judged to be satisfactory, given the relatively small sample size (N = 30) on which the item analysis was based. A possible explanation for the lower than expected reliability estimate can be attributed to the fact that six items on the scale had negative Cureton (1966) item-to-total correlations. More detailed results of the item analysis for the teacher scale are found in Appendix E.

As noted in Chapter 4, the teacher mathematical problem solving attitude scale was developed according to the same plan as the student attitude scale. Because of its careful development, content validity and face validity of the scale may be inferred (Nunnally, 1967). Other types of validity, such as concurrent or construct validity may be inferred for the instrument as it receives use with other populations in conjunction with measures of the same or similar traits.

Data for Question 3

The third question investigated in this study was: How do fourth graders perform on a test of problem solving performance which provides measures of comprehension, application, and problem solving? In order to answer this question, a mathematical problem solving test developed by Romberg and Wearne (see Wearne, in preparation) was administered to the students in the 30 fourth-grade mathematics classes participating in Part I of the study.

The mathematical problem solving test was described in detail in Chapter 4. Each of the 22 three-part items on the test contains a comprehension, an application, and a problem solving question. Thus, three separate scores, rather than a single total score, are reported for each child. Table 6.12 lists the Hoyt reliability estimates for each of the parts of the problem solving test for the DMP and non-DMP samples; total test reliabilities are also included in the table. A complete discussion of the psychometric properties of the test can be found in Wearne (in preparation).

The results of the administration of the mathematical problem solving test are summarized in Table 6.13. The comprehension items on the test assess a child's understanding of information presented either explicitly or implicitly in the item stem. As Table 6.13 indicates, the mean number of comprehension items solved correctly by the students in the fourth-grade sample was 15.00. The application items on the tests involve fairly straightforward applications of a

TABLE 6.12

HOYT RELIABILITIES OF MATHEMATICAL PROBLEM SOLVING TEST FOR DMP AND NON-DMP SAMPLES

	Items	Number of Items	Reliability	Standard Error
DMP	Comprehension	22	.63	1.9
	Application	22	.71	2.0
	Problem Solving	22	.60	1.6
	Total Test	66	.84	3.2
NON-DMP	Comprehension	22	.74	1.9
	Application	22	.79	1.9
	Problem Solving	22	.64	1.5
	Total Test	66	.89	3.1

TABLE 6.13

MATHEMATICAL PROBLEM SOLVING PERFORMANCE SCORES OF STUDENTS (N = 611)

Items	Number of Items	Min./Max.	Mean	St. Dev.
Comprehension	22	2/22	15.00	3.5
Application	22	1/20	9.50	3.9
Problem Solving	22	0/15	3.19	2.5

rule or concept to a situation. The mean number of application items solved correctly was 9.50. Each of the problem solving items on the test presents a situation which involves other than a routine application of some principle; and so, neither the solution nor the method of solution is readily apparent. The mean number of problem solving items correctly solved by the fourth graders in the sample was 3.19. The decrease in mean number of problems solved correctly for each of the types listed in Table 6.13 is not surprising, but, rather is to be expected since each application item is more difficult than its preceding comprehension item, and each problem solving item is more difficult than its preceding application item.

One of the ancillary queries related to Question 3 of the study was the following: Do differences in problem solving performance exist when students are classified by sex? The second ancillary query was: Do differences in problem solving performance exist when students are classified by mathematics program type: DMP versus non-DMP? In an attempt to answer these two questions, sex-by-program type analyses of variance were performed on the student comprehension, application, and problem solving data. Tables 6.14 to 6.18 summarize the results of this phase of the data analyses. Table 6.14 gives the problem solving scores of students categorized by sex, and the problem solving scores of students categorized by program type are shown in Table 6.15. The results of the ANOVA for the comprehension, the application, and the problem solving scores are shown in Tables 6.16, 6.17, and 6.18, respectively.

TABLE 6.14

MATHEMATICAL PROBLEM SOLVING SCORES OF STUDENTS CATEGORIZED BY SEX

Items	Boys (N=331)			Girls (N=280)		
	Min./Max.	Mean	St. Dev.	Min./Max.	Mean	St. Dev.
Comprehension	4/22	14.80	3.6	2/22	15.25	3.3
Application	2/20	9.54	4.0	1/19	9.43	3.8
Problem Solving	0/15	3.27	2.7	0/15	3.10	2.2

TABLE 6.15

MATHEMATICAL PROBLEM SOLVING SCORES OF STUDENTS CATEGORIZED BY PROGRAM TYPE

	DMP (N=316)			Non-DMP (N=295)		
Items	Min./Max.	Mean	St. Dev.	Min./Max	Mean	St. Dev.
Comprehension	7/22	15.52*	3.1	2/22	14.46	3.8
Application	2/20	9.99*	3.6	1/19	8.95	4.2
Problem Solving	0/15	3.27	2.4	0/15	3.11	2.5

* Significant at $p < .01$

TABLE 6.16

ANOVA FOR COMPREHENSION SCORES

Source	df	MS	F	p <
Sex	1	29.93	2.55	.1111
Program Type	1	152.17	12.95	.0003
Sex X Program Type	1	45.91	3.91	.0486
Error	607	11.75		

TABLE 6.17

ANOVA FOR APPLICATION SCORES

Source	df	MS	F	p <
Sex	1	1.79	.12	.7301
Program Type	1	151.53	10.06	.0016
Sex X Program Type	1	52.87	3.51	.0615
Error	607	15.06		

TABLE 6.18

ANOVA FOR PROBLEM SOLVING SCORES

Source	df	MS	F	p <
Sex	1	4.44	.72	.3975
Program Type	1	3.77	.61	.4353
Sex X Program Type	1	1.90	.31	.5799
Error	607	6.19		

Table 6.14 shows that the mean comprehension score for girls was higher than that for boys, but, as evidenced by the ANOVA for comprehension in Table 6.16. this difference was not significant at the .05 level. Table 6.14 also indicates that boys' mean application and problem solving scores were higher than those of the girls in the sample, but the differences in performance were not significant (see Tables 6.17 and 6.18).

When the mathematical problem solving scores of students were categorized by program type (Table 6.15) DMP students' performance was better than that of the non-DMP students on each part of the problem solving test. The ANOVAs in Tables 6.16, 6.17, and 6.18 indicate that the differences in performance were significant at the .01 level for comprehension and application scores, but were not significantly different for problem solving scores at this or the .05 level.

Table 6.19 presents the problem solving scores of students categorized by sex within program type. Mean performance of DMP boys was consistently higher than that of DMP girls on each of the three parts of the test. On the other hand, in the non-DMP sample, the mean performance of girls was higher than that of boys on comprehension and application, but the mean problem solving score of boys was higher than that of girls. Table 6.16 shows that there was a significant ($p < .05$) sex-by-program type interaction for the

TABLE 6.19

MATHEMATICAL PROBLEM SOLVING SCORES OF STUDENTS CATEGORIZED BY SEX WITHIN PROGRAM TYPE

	DMP		Non-DMP	
Items	Boys (N=168)	Girls (N=148)	Boys (N=163)	Girls (N=132)
Comprehension				
Mean	15.57	15.46	14.01	15.01
St. Dev.	3.2	3.1	3.9	3.5
Application				
Mean	10.32	9.62	8.73	9.21
St. Dev.	3.7	3.5	4.1	4.2
Problem Solving				
Mean	3.41	3.12	3.14	3.08
St. Dev.	2.7	2.1	2.7	2.4

comprehension results and a similar interaction approaching significance ($p < .06$) for the application results. No such interaction was apparent with respect to the problem solving scores.

Data for Question 4

The fourth question of the study was as follows: What is the relationship between fourth-grade students' attitudes toward problem solving and their performance in problem solving? The DSTAT2 program (Wetterstrand, Learn, & Wolfe, 1973) at the University of Wisconsin Academic Computing Center was used to calculate several correlation matrices in an effort to answer this question and its ancillary queries. The DSTAT2 program computes a covariance matrix between two variables using the following computational formula:

$$m_{ij} = \frac{1}{N-1} \sum_{n=1}^{N} (X_{ni} - \bar{X}_i)(X_{nj} - \bar{X}_j).$$

In this formula m_{ij} represents the i, j^{th} element in the matrix. This covariance matrix is then used to compute a product moment correlation matrix with i,j^{th} element according to the following formula:

$$r_{ij} = \frac{m_{ij}}{\sqrt{m_{ii} m_{jj}}}$$

The program utilizes a bivariate subsample method for missing data; each subsample consists of data pairs in which the data values for both variables in the pair are present.

Another option of the DSTAT2 program is the use of a transformation recommended by Hayes (1973) for testing the significance of a given correlation coefficient. This algorithm is Fisher's Z-transformation and is defined by the following formula:

$$Z_{jk} = \frac{\sqrt{N - 3}}{2} \cdot \log_e \left(\frac{1 + r_{jk}}{1 - r_{jk}} \right).$$

Corresponding to each value of Z_{jk} is a significance test probability which is the probability that a unit normal variate is greater than $|Z_{jk}|$. If the test probability is less than a given level of significance, then the corresponding correlation is significantly different from zero at the given significance level. The Fisher Z-transformation was used as a test of significance for the correlation coefficients in the present study.

The correlation matrix for students' mathematical problem solving attitude and performance scores is presented in Table 6.20. Correlations between the three student attitude scores and the three problem solving scores are shown in the table. Significant positive correlations ($p < .01$) exist between each of the attitude scores and each of the problem solving scores. Aside from the strong intercorrelations which exist between the various parts of each instrument, the strongest correlations are found between students' Part II attitude scores and and their comprehension, application, and problem solving scores. Part II of the attitude scale assesses students' reactions to such

TABLE 6.20

CORRELATION MATRIX FOR STUDENTS' MATHEMATICAL PROBLEM SOLVING ATTITUDES AND MATHEMATICAL PROBLEM SOLVING PERFORMANCE (N = 579)

	Att. I	Att. II	Total Att.	Comp.	Appl.	Prob. S.
Att. I	1.00					
Att. II	.55*	1.00				
Total Att.	.82*	.93*	1.00			
Comp.	.12*	.24*	.21*	1.00		
Appl.	.15*	.31*	.27*	.69*	1.00	
Prob. S.	.15*	.25*	.23*	.49*	.69*	1.00

*significant at $p < .01$

things as problem solving techniques or problem situations, and to the frustration or anxiety experienced when confronted with various problem solving situations.

One of the ancillary queries related to Question 4 of the study was: Do differences in this relationship (between attitudes toward problem solving and performance in problem solving) exist if students are classified by sex? Table 6.21 summarizes the correlations between student attitude and problem solving scores classified by sex. As evidenced by the data in the table, significant positive

TABLE 6.21

CORRELATIONS BETWEEN STUDENT ATTITUDE SCORES AND STUDENT PROBLEM SOLVING SCORES CLASSIFIED BY SEX

	Problem Solving Items	Attitude		
		Part I	Part II	Total
Boys (N=312)	Comprehension	.11**	.33**	.27**
	Application	.17**	.36**	.32**
	Problem Solving	.15**	.27**	.25**
Girls (N=267)	Comprehension	.13*	.12*	.14*
	Application	.12*	.24**	.21**
	Problem Solving	.15*	.23**	.22**

* significant at $p < .05$
** significant at $p < .01$

correlations exist, for both boys and girls, between each of the attitude scores and each of the problem solving scores. Though all correlations for the boys' data are significant at the .01 level, some correlations in the girls' data are significant only at the .05 level. The correlations between boys' Part II and Total attitude scores and each of their problem solving test scores are clearly higher than those of the girls for corresponding scores. However, the correlation between girls' Part I attitude scores and their comprehension scores is higher than that of the boys; the girls' correlation is significant only at the .05 level, while that for the boys is significant at the .01 level. This seeming inconsistency in significance levels can be explained because there were fewer girls than boys in the sample, and the Fisher Z-transformation used for the significance test is dependent upon the number of subjects in the sample.

The second ancillary query for Question 4 was the following: Do differences in this relationship (between attitudes toward problem solving and performance in problem solving) exist if students are classified by mathematics program type: DMP versus non-DMP? The correlations between student attitude and problem solving scores classified by program type are shown in Table 6.22. As the table indicates, all correlations are positive. However, those for the non-DMP sample are all significant at the .01 level and are clearly stronger than those of the DMP sample. Only four of the correlations were significant at the .01 level for the DMP sample, and very weak relationships are shown between Part I and Total attitude scores and the comprehension scores for the DMP sample.

Exploratory Analyses for Question 4

As a result of the rather weak relationships found between DMP student problem solving attitude and performance (see Table 6.22), additional data analyses were undertaken to explore those relationships. In an analysis of the psychometric characteristics of the

TABLE 6.22

CORRELATIONS BETWEEN STUDENT ATTITUDE SCORES AND STUDENT PROBLEM SOLVING SCORES CLASSIFIED BY PROGRAM TYPE

	Problem Solving Test	Attitude		
		Part I	Part II	Total
DMP (N=302)	Comprehension	.03	.12*	.09
	Application	.11	.17**	.16**
	Problem Solving	.12*	.16**	.16**
non-DMP (N=277)	Comprehension	.21**	.35**	.34**
	Application	.20**	.43**	.39**
	Problem Solving	.18**	.34**	.31**

* significant at p < .05

** significant at p < .01

mathematical problem solving test, Wearne (in preparation) performed a cluster analysis on the DMP problem solving test results obtained in the present study. Using Ward's cluster analysis procedure (see Johnson, 1967), four clusters of students were identified. Two of those clusters were of interest for the exploratory analyses described here. The first cluster included 15 students who had shown high performance on the problem solving test; the mean scores for those students are shown in Table 6.23. The second cluster included 91 students who had demonstrated low performance on the problem solving test; their mean scores are also shown in Table 6.23.

TABLE 6.23

MATHEMATICAL PROBLEM SOLVING SCORES OF STUDENTS IN HIGH (N=15) AND LOW (N=91) CLUSTERS

Cluster	Items	Mean	Standard Deviation
High	Comprehension	19.46	1.9
	Application	16.92	1.8
	Problem Solving	10.07	1.9
Low	Comprehension	11.93	2.1
	Application	6.27	1.7
	Problem Solving	1.59	1.1

The high cluster and the low cluster were utilized because it was felt that the problem solving attitudes of the students in those clusters might be more predictable than those in the other two clusters; that is, one would expect good problem solvers to have favorable attitudes toward problem solving and poor problem solvers to possess less than favorable attitudes toward problem solving. As indicated in Table 6.24, those conjectures were indeed borne out by the data for the high and low problem solving clusters. Students' mean total attitude score in the high cluster was approximately 13 points above the mean score for the DMP sample (see Table 6.4).

TABLE 6.24

MATHEMATICAL PROBLEM SOLVING ATTITUDE SCORES OF STUDENTS IN HIGH (N=13) AND LOW (N=82) CLUSTERS

Cluster	Scale Part	Mean	Standard Deviation
High	I (Informal)	47.8	8.5
	II (Formal)	93.8	10.4
	Total	141.6	16.5
Low	I (Informal)	42.7	7.3
	II (Formal)	84.5	10.2
	Total	127.2	14.5

The mean total attitude score of students in the low cluster was about two points below the mean for all DMP students in the sample.

Product moment correlations were also computed between student attitude scores and student problem solving scores within the high and low clusters. These are given in Table 6.25. Within the low cluster correlations were weak and rather inconsistent; for students who are poor problem solvers this result is, perhaps, not surprising. Within the high cluster, the correlations between attitude scores and comprehension scores were negative; on the other hand, for the

TABLE 6.25

CORRELATIONS BETWEEN STUDENT ATTITUDE SCORES AND STUDENT PROBLEM SOLVING SCORES WITHIN HIGH AND LOW CLUSTERS

Cluster	Problem Solving Items	Attitude		
		Part I	Part II	Total
	Comprehension	-.15	-.38	-.32
High	Application	.36	.16	.28
	Problem Solving	.32	.24	.32
	Comprehension	-.19	-.01	-.10
Low	Application	.15	.11	.15
	Problem Solving	.10	.01	.05

application and problem solving scores, the correlations were positive and somewhat stable. The results for the high cluster seem to indicate a negative relationship between attitude scores and scores on those problem solving items which good problem solvers might not find particularly interesting; however, for the items that better problem solvers might find intriguing, there were stronger correlations between attitude and performance.

The results of the additional analyses performed with the DMP sample suggest that, with groups of students for whom there are marked differences in problem solving performance, there are also differences in problem solving attitude. These results seem to indicate that, at least for this sample, differences in problem solving attitude may be dependent upon who the students are, that is, whether good, poor, or other types of problem solvers. The results also suggest that the relationships between problem solving attitude and performance may vary according to the caliber of students' problem solving performance.

Data for Question 5

The fifth question of the study was the following: What is the relationship between fourth-grade teachers' attitudes toward problem solving and their students' performance in problem solving? In order to answer this question, mean student scores were calculated by class for each of the three parts of the problem solving test. Table 6.26 summarizes the teacher attitude scores and the mean student problem solving scores by class. In an effort to determine the relationship between the teacher scores and the mean student scores, product moment correlations were computed. Those correlations are presented in Table 6.27. For the fourth-grade classes involved in the present study, very weak and non-significant negative relationships existed between teachers' problem solving attitudes and their students' mean problem solving performance on each of the three parts of the mathematical problem solving test.

TABLE 6.26

TEACHER ATTITUDE SCORES AND MEAN STUDENT PROBLEM SOLVING SCORES BY CLASS

Class No.	Class Size	Teacher Attitude Score	Mean Student Scores		
			Comprehension	Application	Problem Solving
1	24	159	13.08	8.33	2.46
2	19	149	16.32	12.58	5.11
3	25	170	13.84	8.32	2.12
4	11	141	18.55	13.64	4.73
5	26	160	15.35	9.42	2.85
6	27	175	14.67	8.63	2.63
7	9	164	17.11	13.67	5.78
8	12	156	16.83	12.17	4.67
9	21	145	16.00	9.71	3.38
10	20	158	14.90	8.80	2.90
11	21	167	15.95	10.33	3.76
12	24	159	16.75	10.33	3.75
13	24	157	16.00	9.79	2.83
14	31	154	16.23	11.65	3.68
15	22	169	14.55	7.86	1.82
16	32	160	12.03	8.06	2.87
17	23	159	16.77	12.36	4.91
18	23	165	14.86	9.38	3.76
19	22	144	14.50	7.06	1.69
20	23	163	15.76	9.81	3.29
21	24	158	15.38	9.86	4.29
22	24	163	13.18	8.09	3.14
23	23	142	14.83	9.00	2.57
24	14	134	10.77	5.23	1.23
25	8	141	17.86	14.00	6.57
26	8	155	13.25	5.37	1.62
27	11	155	13.36	8.36	2.27
28	15	165	15.73	9.73	2.93
29	20	154	16.85	11.20	3.95
30	25	153	14.28	8.12	2.80

TABLE 6.27

CORRELATIONS BETWEEN TEACHER MATHEMATICAL PROBLEM SOLVING ATTITUDE AND MEAN STUDENT MATHEMATICAL PROBLEM SOLVING PERFORMANCE

	Comprehension	Application	Problem Solving
Teacher Attitude	-.05	-.06	-.08

The first ancillary query related to Question 5 was: Do differences in this relationship (between teachers' attitudes toward problem solving and their students' performance in problem solving) exist if students are classified by sex? Table 6.28 gives the product moment correlations that were calculated between teacher attitude scores and the mean problem solving scores for

TABLE 6.28

CORRELATIONS BETWEEN TEACHER MATHEMATICAL PROBLEM SOLVING ATTITUDE AND MEAN MATHEMATICAL PROBLEM SOLVING PERFORMANCE: BOYS VERSUS GIRLS

	Girls			Boys		
	Comp.	Appl.	Prob. S.	Comp.	Appl.	Prob. S.
Teacher Attitude	.08	.10	.16	-.16	-.17	-.19

the boys and girls in their classes. The correlations in this table suggest a weak, non-significant positive relationship between girls' problem solving performance and their teachers' attitudes toward problem solving. On the other hand, the data in the table suggest a weak, non-significant, negative relationship between boys' problem solving performance and their teachers' attitude toward problem solving. The data here must be viewed and interpreted with some caution, however, as three of the participating classes had fewer than 10 students. Thus, cell sizes are extremely small for several classes when computing mean performance by sex of the student. The findings in Table 6.28 are suggestive at best.

The second ancillary query for Question 5 of the study was as follows: Do differences in this relationship (between teachers' attitudes toward problem solving and their students' performance in problem solving) exist if students are classified by mathematics program type: DMP versus non-DMP? In the descriptive statistics presented earlier in Table 6.26, classes 1-15 are from the DMP sample, and classes 16-30 are from the non-DMP sample. The correlation coefficients between teacher attitude and mean student performance by program type are given in Table 6.29. Strong negative relationships existed between DMP teacher attitudes and the problem solving performance of their students. Using the Fisher Z-transformation as a significance test, the correlations between DMP teacher attitude and the mean comprehension and

TABLE 6.29

CORRELATION BETWEEN TEACHER MATHEMATICAL PROBLEM SOLVING ATTITUDE AND MEAN STUDENT MATHEMATICAL PROBLEM SOLVING PERFORMANCE: DMP VERSUS NON-DMP

	DMP			Non-DMP		
	Comp.	Appl.	Prob. S.	Comp.	Appl.	Prob. S.
Teacher Attitude	-.59*	-.55*	-.47	.16	.18	.19

* Significant at $p < .05$

application scores of their students were found to be significant at the .05 level; the correlation between DMP teacher attitude and mean student problem solving scores was not significant at the .05 level. The correlations for the non-DMP sample, on the other hand, are all positive, but non-significant. As a result of the negative correlations found between teacher attitude and mean problem solving performance of their students, several exploratory analyses were undertaken in an effort to explain these rather surprising results.

Exploratory Analyses for Question 5

This section briefly describes data analyses undertaken to explore the substantial negative correlations which were found in the DMP sample between teacher problem solving attitude and student problem solving performance. Once computer error was ruled out as a possible explanation, the PICT1 program (Allen, Learn, Schlater, & Wolfe, 1975) was utilized to obtain scatter plots of DMP teacher attitude scores and the mean comprehension, application, and problem solving scores of their students. These scatter plots are included in Appendix F. The negative correlations shown in Table 6.29 were verified by the scatter plots; thus, a rather clear negative relationship in the data was apparent.

Fletcher (1968) has observed that relationships based on class means should be interpreted with great care, since extreme observations may have a significant effect on mean score for the class. In an attempt to determine if there were extreme observations in the DMP sample, "massive" scatter plots were obtained for all student comprehension, application, and problem solving scores in the sample. Each student score was plotted against teacher attitude score for each of the 15 classes. No extreme observations were apparent in individual student scores, but the "massive" scatter plots also verified the negative trend in the data. The "massive" scatter plots are not included in this paper as the size of the computer printouts prohibited their reduction to a size which would maintain legibility of the data.

As the data were examined, it was noted that the teacher with the lowest attitude score taught a class whose mean problem solving score was 5.19; on the other hand, the class whose teacher had the highest attitude score had a mean problem solving score of 2.55. The problem solving scores of these two classes reflected the homogeneity of each class; that is, the class with low problem solving mean was a slow group of students, while the group with the higher mean was above-average in mathematical ability. In fact, the above-average class had received instruction in approximately four more DMP topics than the slower group. Thus, the data of the present sample seem to indicate that the problem solving performance of students may be more related to opportunity to learn than to teacher problem solving attitude.

The data analyses for Question 5 of the study suggest that the results may be an artifact of this group of teachers and students. Though a rather clear negative trend in the relationship between DMP teacher attitude and student performance was apparent, it must be noted that the DMP data are based upon a small, selected sample of teachers, all of whom expressed favorable attitudes toward mathematical problem solving; thus, variance in attitude scores was slight. In this situation, when only a small portion of the distribution for the total population is examined, Hayes (1973) has observed that generalizations about the true nature of the relationships among the variables should be viewed with extreme caution.

Concluding Remarks

This part of Chapter 6 has discussed the analysis and interpretation of the data for the five main questions and several ancillary questions investigated in Part I of the study. Conclusions resulting from the discussion in the various sections of this part of the chapter will be presented in Chapter 7. The next part of the present chapter discusses the analysis and interpretation of the data for the two main and two ancillary questions investigated in Part II of the study.

Analysis and Interpretation of the Data for Part II

The second part of the study was directed at the two remaining major questions posed in Chapters 1, 3, and 5. Those questions pertained to the directional relationships existing between teacher problem solving attitudes and student problem solving performance and attitudes. Simple correlational procedures cannot answer such questions of cause and effect. However, Campbell and Stanley (1963) have discussed a quasi-experimental design which can provide clues regarding the direction of relationship between teacher attitude and student attitude and performance. The design employs time as a third variable and is called cross-lagged panel correlation. This design was employed for the second part of the present study; a complete description of the design was given in Chapter 3 and discussed again in Chapter 5.

The basic plan for Part II of this study involved problem solving testing at two different times (Time 1 and Time 2), with an intervening "treatment" period. Only the DMP sample of teachers and students was involved in this part of the study. At each testing time three instruments were administered: (1) the student mathematical problem solving test; (2) the student mathematical problem solving attitude scale; and (3) the teacher mathematical problem solving attitude scale. The "treatment" was not rigidly controlled, but did entail instruction from the regular sequence of DMP topics. The cross-lagged panel correlational technique, as recommended by Campbell and Stanley (1963) for this type of study, will be discussed as the data for each question are presented.

Data for Question 6

The sixth question of the study was the following: Do fourth-grade teachers' attitudes toward problem solving affect their students' problem solving performance or is the effect of the opposite nature? In an effort to answer this question, teacher problem solving attitude data and student problem solving performance data were gathered at two different times (Time 1 and Time 2). The descriptive statistics for these data are presented in Table 6.30. Fifteen DMP classes particiapted in this part of the stdy. However, the teacher of Class 9 who

TABLE 6.30

DESCRIPTIVE STATISTICS FOR TEACHER ATTITUDE AND STUDENT PERFORMANCE AT TIME 1 AND TIME 2

Class Number	Time 1				Time 2			
	Teacher Attitude Score	Mean Student Scores*			Teacher Attitude Score	Mean Student Scores*		
		C	A	P		C	A	P
1	159	13.08	8.33	2.46	161	14.70	10.85	4.37
2	149	16.32	12.58	5.11	151	18.11	14.28	6.94
3	170	13.84	8.32	2.12	179	15.00	9.97	3.76
4	141	18.55	13.64	4.73	170	18.73	15.64	7.55
5	160	15.35	9.42	2.85	160	15.92	12.52	4.28
6	175	14.67	8.63	2.63	168	14.30	10.00	3.41
7	164	17.11	13.67	5.78	160	17.42	14.17	6.50
8	156	16.83	12.17	4.67	163	17.45	14.36	5.82
9	145	16.00	9.71	3.38	**	15.11	10.95	3.53
10	158	14.90	8.80	2.90	172	16.48	11.52	5.48
11	167	15.95	10.33	3.76	170	15.91	11.04	5.65
12	159	16.75	10.33	3.75	166	16.96	12.24	5.12
13	157	16.00	9.79	2.83	171	15.54	11.46	4.65
14	154	16.23	11.65	3.68	153	15.15	11.08	4.35
15	169	14.55	7.86	1.82	171	14.76	11.08	3.92

* C: Comprehension
A: Application
P: Problem Solving

** Not available

participated at Time 1 resigned prior to the testing period at Time 2; thus, complete data were available for only 14 classes. In addition to the teacher attitude scores at Time 1 and Time 2, Table 6.30 gives the mean student scores on each part of the problem solving test.

The rather substantial negative correlations found between DMP teacher problem solving attitudes and mean student problem solving performance at Time 1 suggested the sagacity of examining these relationships at Time 2 as well. The correlations for Time 2 are presented in Table 6.31. Though the relationships between teacher attitude and mean student performance at Time 2 are also negative, the correlations are not significant, and the relationships are much weaker than at Time 1. These findings, however, support the negative trend observed in the data at Time 1.

TABLE 6.31

CORRELATIONS OF TEACHER ATTITUDE AND STUDENT PROBLEM SOLVING PERFORMANCE AT TIME 2

	Comprehension	Application	Problem Solving
Teacher Attitude	-.27	-.39	-.28

Another point worthy of note is that the correlation between teacher attitude scores at Time 1 and teacher attitude scores at Time 2 was .41. A stronger relationship between adult attitudes at two different times might have been expected. This finding suggests that either the attitudes of the teachers in this sample are rather unstable or that the internal consistency of the teacher attitude scale needs to be improved. It is possible, of course, that both of these observations are true. At any rate, the data reported in Table 6.31 and in this paragraph support the contention expressed earlier in this paper that the findings of the study regarding the relationship between DMP teacher attitude and student performance are suggestive and warrant further investigation.

As noted previously, merely calculating the correlations between teacher scores and student scores for each time period does not provide information regarding cause and effect as posed in Question 6 above. Instead, cross-lagged panel correlations (Campbell & Stanley, 1963) were computed. The correlation between teachers' attitude scores at Time 1 and their students' mean problem solving scores at Time 2 (r_{12}) were calculated, as was the correlation between teacher attitudes at Time 2 and the means of the problem solving scores of their students at Time 1 (r_{21}). These correlations are shown in Table 6.32. Campbell and Stanley (1963) suggest that if one of the cross-lagged

TABLE 6.32

CROSS-LAGGED CORRELATIONS: TIME 1 TEACHER ATTITUDE WITH TIME 2 STUDENT PERFORMANCE (r_{12}) AND TIME 2 TEACHER ATTITUDE WITH TIME 1 STUDENT PERFORMANCE (r_{21})

Cross-lagged Correlations	Comprehension	Application	Problem Solving
r_{12}	-.72	-.72	-.69
	*	*	*
r_{21}	-.25	-.50	-.53

* significant difference in correlations at $p < .01$

correlations is signficantly more positive than the other, then this provides evidence regarding which variable has the greater effect on the other.

Hayes (1973) has suggested a method of testing the significance of the difference between two correlation coefficients. This method is based upon the Fisher Z-transformation, and the test statistic is provided by the ratio

$$\frac{Z_1 - Z_2}{\sigma_{(Z_1 - Z_2)}},$$

where Z_1 represents the transformed value of the correlation coefficient for the first sample, Z_2 the transformed value for the second, and

$$\sigma_{(Z_1 - Z_2)} = \sqrt{\frac{1}{N_1 - 3} + \frac{1}{N_2 - 3}} .$$

The test statistic in the preceding paragraph was employed to determine the signifiance of the differences between the pairs of correlations in Table 6.32. As noted in the table, each of the differences is significant at $p < .01$. Since r_{21} is significantly more positive than r_{12} for each of the parts of the mathematical problem solving test, it may be inferred that initial mean student problem solving performance had a greater effect on final teacher attitudes than initial teacher attitudes had on final mean student problem solving performance.

The ancillary question related to Question 6 dealt with the directional relationship between teacher attitudes and student performance when the data are grouped by sex of the student. Table 6.33 presents the cross-lagged correlations which were computed separately for boys and girls. For each part of the mathematical problem solving test, r_{21} is more positive than r_{12}. However, the difference between r_{21} and r_{12} for boys on the third part of the mathematical problem solving test is not significant. For girls, the directional relationship between teacher attitude and student performance is the same as for the

TABLE 6.33

CROSS-LAGGED CORRELATIONS FOR BOYS VERSUS GIRLS: TIME 1 TEACHER ATTITUDE WITH TIME 2 STUDENT PERFORMANCE (r_{12}) AND TIME 2 TEACHER ATTITUDE WITH TIME 1 STUDENT PERFORMANCE (r_{21})

Cross-lagged Correlations		Comprehension	Application	Problem Solving
Boys	r_{12}	-.57	-.73	-.52
		*	*	
	r_{21}	-.26	-.47	-.51
Girls	r_{12}	-.73	-.56	-.68
		*	*	*
	r_{21}	-.19	-.36	-.47

* significant difference in correlations at $p < .01$

total sample; that is, girls' initial mean problem solving performance had a greater effect on final teacher attitudes than initial teacher attitudes had on girls' final mean problem solving performance. For boys, however, the preceding inference could only be made for comprehension and application parts of the problem solving test. The inferences made with regard to the directional relationships based on comparisons of boys' and girls' correlations must be viewed with some caution. As noted earlier in Table 6.26 three of the DMP classes had fewer than 15 students, and so the computation of mean scores by sex of the student was based upon very small cell sizes for those classes.

Data for Question 7

The last major question of the present study was as follows: Do fourth-grade teachers' attitudes toward problem solving affect their students' attitudes toward problem solving or is the effect of the opposite nature? Teacher and student problem solving attitude data were gathered at two different times (Time 1 and Time 2) in an attempt to answer Question 7. Table 6.34 gives the descriptive statistics for these data. As was noted for Question 6, complete data were available only for 14 of the 15 DMP classes in the sample as one class changed teachers between the first and second testing periods. Besides the teacher attitude scores, Table 6.34 lists the mean student responses on each part of the mathematical problem solving attitude scale.

Once again, rather than calculating simple correlations between teacher and student attitude scores, the cross-lagged panel correlational technique was employed. The correlation between teachers' attitudes at Time 1 and the means of the problem solving attitude scores of their students at Time 2 (r_{12}) were computed, as well as the correlation between teacher attitudes at Time 2 and the means of the problem solving attitude scores of their students at Time 1 (r_{21}). Table 6.35 gives these correlations. The

TABLE 6.34

DESCRIPTIVE STATISTICS FOR TEACHER ATTITUDE AND STUDENT ATTITUDE AT TIME 1 AND TIME 2

Class Number	Time 1				Time 2			
	Teacher Attitude Score	Mean Student Scores*			Teacher Attitude Score	Mean Student Scores*		
		I	II	Total		I	II	Total
1	159	45.85	86.38	132.23	161	44.58	87.50	132.08
2	149	45.06	86.50	131.56	151	41.40	89.00	130.40
3	170	41.58	86.65	128.23	179	44.70	89.59	134.30
4	141	39.82	82.91	122.73	170	39.78	84.67	124.44
5	160	41.87	86.25	128.12	160	45.64	89.64	135.29
6	175	42.07	84.11	126.19	168	42.46	84.42	126.88
7	164	52.00	99.55	151.55	160	51.79	95.93	147.71
8	156	47.31	93.31	140.62	163	44.00	95.09	139.09
9	145	44.05	90.21	134.26	**	44.00	92.16	136.16
10	158	43.00	87.61	130.61	172	40.91	85.91	126.82
11	167	39.38	79.00	118.38	170	39.42	82.96	122.37
12	159	44.04	85.50	129.54	166	47.31	88.19	135.50
13	157	41.56	83.64	125.20	171	39.64	84.24	123.88
14	154	42.19	83.87	126.06	153	42.48	88.56	131.04
15	169	40.92	80.04	120.96	171	42.89	87.46	130.36

* I: Part I (Informal)
II: Part II (Formal)
Total: Composite

** Not available

Fisher Z-transformation ratio described in the data analysis section for Question 6 was utilized to determine the signficiance of the differences between the pairs of correlations in Table 6.35.

TABLE 6.35

CROSS-LAGGED CORRELATIONS: TIME 1 TEACHER ATTITUDE WITH TIME 2 STUDENT ATTITUDE (r_{12}) AND TIME 2 TEACHER ATTITUDE WITH TIME 1 STUDENT ATTITUDE (r_{21})

Cross-lagged Correlations	Attitude I	Attitude II	Total
r_{12}	.29	-.03	.13
	*	*	*
r_{21}	-.47	-.30	-.37

*significant difference in correlations at $p < .01$

Each of the differences is significant at $p < .01$. Using the inferential procedure recommended by Campbell and Stanley (1963), since r_{12} is significantly more positive than r_{21}, initial teacher attitude seemed to have a greater effect on final student attitude than initial student attitude had on final teacher attitude.

The last ancillary question of the study pertained to the directional relationship between teacher attitudes and student attitudes when the data are grouped by sex of the student. Cross-lagged panel correlations were computed separately for boys and girls and are presented in Table 6.36. For each part of the attitude scale r_{12} is significantly more positive than r_{21} for both boys and girls. However, the level of significance for the differences in correlations based on the second part of the attitude scale is $p < .05$, whereas those based on the first part and the total scale are signficant at $p < .01$. Thus, the same directional

TABLE 6.36

CROSS-LAGGED CORRELATIONS FOR BOYS VERSUS GIRLS: TIME 1 TEACHER ATTITUDE WITH TIME 2 STUDENT ATTITUDE (r_{12}) AND TIME 2 TEACHER ATTITUDE WITH TIME 1 STUDENT ATTITUDE (r_{21})

	Cross-lagged Correlations	Attitude I		Attitude II		Total	
Boys	r_{12}	.14	**	-.16	*	-.02	**
	r_{21}	-.41		-.34		-.37	
Girls	r_{12}	.33	**	.04	*	.20	**
	r_{21}	-.45		-.18		-.30	

* significant difference in correlations at $p < .05$
** significant difference in correlations at $p < .01$

relationships hold between teacher attitude and student attitude for boys and girls separately as held for the total sample. However, the conclusion is somewhat tenuous for the relationship based on the second part of the student attitude scale. And once again, the inferences made for boys versus girls must be viewed with some caution because of the very small cell size used to calculate mean student attitude scores for three of the participating classes.

Concluding Remarks

The analysis and interpretation of the data for Part II of the study have been discussed in the last section of the chapter; data were presented for two main and two ancillary questions. The first part of the chapter described the data for the five main and several ancillary questions for Part I of the study. Conclusions evolving from all data analyses will be discussed in Chapter 7, which presents the conclusions and recommendations of the study.

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TECHNICAL REPORT NO. 396
(Part 2 of 2 Parts)

a study of the relationships between selected noncognitive factors and the problem solving performance of fourth-grade children

SEPTEMBER 1976

WISCONSIN RESEARCH
AND DEVELOPMENT
CENTER FOR
COGNITIVE LEARNING

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Part 2 of 2 Parts

A STUDY OF THE RELATIONSHIPS BETWEEN SELECTED NONCOGNITIVE FACTORS AND THE PROBLEM SOLVING PERFORMANCE OF FOURTH-GRADE CHILDREN

by

Donald Ray Whitaker

Report from the Project on
Conditions of School Learning and Instructional Strategies

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Faculty Associate

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Center for Cognitive Learning
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Madison, Wisconsin

September 1976

This Technical Report is a doctoral dissertation reporting research supported by the Wisconsin Research and Development Center for Cognitive Learning. Since it has been approved by a University Examining Committee, it has not been reviewed by the Center. It is published by the Center as a record of some of the Center's activities and as a service to the student. The bound original is in the University of Wisconsin Memorial Library.

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ABSTRACT

The purpose of this study was to investigate the relationships between the mathematical problem solving performance of fourth grade children, their attitudes toward mathematical problem solving, their teachers' attitudes toward mathematical problem solving, and related sex and program-type differences.

Three instruments were used to gather data. The 22-item mathematical problem solving test (Romberg & Wearne, 1976) provides a measure of comprehension, application, and problem solving for each item. The 36-item student mathematical problem solving attitude scale and the similar 40-item teacher scale have Likert-type formats and were developed by the investigator.

During the fourth month of the 1975-76 school year data were gathered for Part I of the study from 30 fourth grade classes in 13 southern Wisconsin schools. Fifteen of the classes were using Developing Mathematical Processes (DMP); the remaining 15 were using standard mathematics textbook series.

Both students and teachers possessed favorable mathematical problem solving attitudes. The DMP students performed significantly better than non-DMP students on the first two parts of the problem

solving test; no significant differences in performance were observed on the third part. Rather stable and significant positive correlations were found between student problem solving performance and student problem solving attitude. Significant negative correlations found between DMP teacher problem solving attitude and mean student performance were judged an artifact of the non-random sampling of classes for the study. No significant sex-related differences were found in any of the data.

The design of Part II of the study was based on the cross-lagged panel correlational technique of Campbell and Stanley (1963). During the seventh month of the 1975-76 school year the 15 DMP classes participated in a second round of problem solving testing. An intervening "treatment" period between the first and second testing times involved instruction in selected DMP topics. Part II attempted to determine the direction of effect between teacher problem solving attitudes and student problem solving attitudes and performance.

Cross-lagged panel correlations indicated that initial student performance seemed to have a greater effect on final teacher attitude than initial teacher attitude had on final student performance. However, initial teacher attitude seemed to have a greater effect on final student attitude than initial student attitude had on final teacher attitude.

Major Professor John G. Harvey

Chapter 7

CONCLUSIONS AND RECOMMENDATIONS

The discussion in this chapter centers on the conclusions and recommendations evolving from the study described in this paper. The chapter begins with a brief summary of the study.

Summary of the Study

The purpose of the present study was to investigate the relationships betwen selected noncognitive factors and the mathematical problem solving performance of fourth-grade children. Those factors investigated were children's attitudes toward mathematical problem solving, teachers' attitudes toward mathematical problem solving, and related sex and program-type differences.

Three instruments were used to gather the data for the study. The 22-item mathematical problem solving test provides a measure of comprehension, application, and problem solving for each item; it was developed by Romberg and Wearne (see Wearne, in preparation). The student mathematical problem solving attitude scale is a 36-item Likert-type scale, and the teacher mathematical problem solving attitude scale is a 40-item scale with Likert format; both attitude scales were developed by the author of the study.

The study was conducted in two parts. Thirty fourth-grade classes in 13 Wisconsin schools participated in Part 1. During the fourth month of the 1975-76 school year, the instruments of the study were administered to the students and teachers in the sample. Fifteen of the classes were using Developing Mathematical Processes (DMP). The remaining 15 classes were not using the DMP materials. Five main questions and nine ancillary questions were investigated in Part I of the study. The main questions dealt with favorableness or unfavorableness of student and teacher attitudes toward mathematical problem solving, performance of students on the mathematical problem solving test, and the relationships between student performance, student attitudes, and teacher attitudes. Ancillary questions dealt with sex-related and program-type differences in the above relationships.

Part II of the study was conducted with only the DMP sample from Part I. During the seventh month of the 1975-76 school year, the 15 DMP classes participated in a second round of testing using an alternate version of the student problem solving test and the student and teacher attitudinal scales. An intervening "treatment" period between the first testing (Time 1) and the second testing (Time 2) involved instruction in topics selected from the regular DMP sequence. The design of the second part of the study was based on the cross-lagged panel correlational technique (Campbell & Stanley, 1963) as advocated by Aiken (1969). This part of the study attempted to determine the direction of effect between teacher problem solving attitudes and student problem solving attitudes and performance. Using cross-lagged panel correlations, teacher attitudes at Time 1 and Time 2 were correlated with student attitudes and performance at Time 1 and Time 2 in order to suggest which variable had the greater influence on the other.

Before discussing the conclusions resulting from the conduct of the study and subsequent data analyses, the limitations of the study are noted. These are discussed in the next section.

Limitations of the Study

Research studies in the behavioral sciences are often limited because of a number of extraneous factors which may influence the results of these studies. Purity of research design must sometimes be sacrificed due to the practical constraints of a "real-world" setting. Campbell and Stanley (1963) provide a reasonably complete discussion of these extraneous and confounding variables. Several factors either limit or confound the results of the present study; the most important of these are discussed here.

Ideally, the fourth-grade classes in the present study should have been randomly selected. However, under the circumstances of the study, random sampling was not possible, and so, even though the number of students participating was quite large, the findings of the study may not be generalizable to all fourth-grade classes.

In addition, the DMP classes in the study had been participants in the large-scale field test of the program for the preceding school year, and the author had worked with the teachers of six of those classes in a number of inservice sessions during that time. The confounding effect of these factors is difficult to ascertain. For example, did these teachers express their true feelings on the teacher problem solving attitude scale, or did they respond in a manner which they thought might be expected?

Instrument validity and reliability can also be limiting factors in a study. Because of careful instrument development, however, content and face validity may be inferred (Nunnally, 1967); such an inference seems reasonable for each of the instrments in this study. And the reliability coefficients for the instruments were also judged to be satisfactory, although the reliability coefficient for the teacher problem solving scale was based on a sample of only 30 teachers. Thus, the findings of the study which are dependent upon use of the teacher scale may be somewhat limited.

The correlational procedures used in the study are based on the assumption of a bivariate normal population. When sample size is large, as was the case for the administration of the student instruments, bivariate normality may be assumed (Hayes, 1973). However, if sample size is relatively small, then Hayes (1973) suggests that the results of correlational procedures must be viewed with caution and may be only suggestive of actual relationships existing in the total population. Thus, in the present study, findings based on the correlations performed with the teacher attitudinal data must be viewed in this light.

Conclusions of the Study

Seven main and several ancillary questions served as the framework around which the study was designed, conducted, and the data analyzed. This section of the chapter is organized in a similar manner. Each major question of the study is given, and then the conclusions pertaining to that question are discussed.

Question 1

The initial question of the study was: Do fourth grade students have favorable attitudes toward problem solving? Based on the 619 students who responded to the problem solving attitude scale in the study, this question must be answered affirmatively. The mean student scores on the scale can be categorized as "favorable." The ancillary queries related to Question 1 inquired as to the existence of sex or program-type differences in fourth graders' attitudes toward problem solving. There were no significant sex-related differences in the problem solving attitudes expressed by the students in the sample; in fact, mean attitude scores were so similar that one might conclude that there were no sex-related differences whatsoever.

When comparing the problem solving attitude scores of students by program-type, the non-DMP students seemed to have slightly more favorable attitudes than the DMP students. On the informal measure of problem solving attitude, the non-DMP students' attitude was significantly more favorable than the DMP students' attitude, although the difference in mean scores was only 1.5 points. On the formal measure of problem solving attitude and on the total scale there were no significant differences in scores based on type of mathematics program studied. In the DMP sample boys had the more favorable problem solving attitudes, while in the non-DMP sample it was the girls who expressed more favorable attitudes toward problem solving. Though this result produced a statistically significant interaction, it probably has little practical significance.

Question 2

The second question of the study was as follows: Do fourth grade teachers have favorable attitudes toward problem solving? The 30 fourth grade teachers in this study did, indeed, express favorable reactions toward problem solving as measured by the teacher problem solving attitude scale. Attitudes of these teachers ranged from what might be termed "slightly" favorable to "very" favorable. Based upon the mean attitude scores of the DMP and non-DMP teachers, it may be concluded that DMP teachers expressed more favorable problem solving attitudes than the non-DMP teachers, although the expressed differences were not statistically significant. As noted above, there was little variation in the range of teacher attitudes.

Question 3

The third question investigated in the study was: How do fourth graders perform on a test of problem solving performance which provides measures of comprehension, application, and problem solving? Three separate scores were reported for each student responding to the mathematical problem solving test used in the study. Students were able to solve correctly more of the comprehension items than application items and more of the application items than problem solving items; this result was expected since it reflects the order of difficulty of the items. The problem solving items are the most difficult and are problems in the sense of the definition given in Chapter 1. Of a total of 22 three-part items on the test, mean number of problems solved correctly by the students was 15.00, 9.50, and 3.19 for comprehension, application, and problem solving, respectively. Satisfactory performance on the problem solving test is difficult to assess without some predetermined criterion level; the establishment of such a criterion level was not deemed appropriate for this study. One fact does emerge, however. Most of the students could not be classified as good problem solvers when the problems are of a type specified by the definition used in the study. A more detailed discussion of student performance on the problem solving test may be found in Wearne (in preparation).

One of the ancillary questions related to Question 3 pertained to the possible existence of sex-related differences in problem solving performance of the students in the sample. The girls' mean performance on the comprehension part of the test was higher than that of the boys; on the other hand, for the application and problem solving sections, the boys outperformed the girls. None of these differences was significant, however.

In the sample for this study DMP students performed significantly better than non-DMP students on the comprehension and application parts of the problem solving test; the difference in performance for the problem solving part of the test was not significant. The better performance of the DMP students is noteworthy, especially since the non-DMP sample received about 10 more days of instruction prior to their testing than did the DMP sample.

Question 4

The fourth question investigated in the study was the following: What is the relationship between fourth grade students' attitudes toward problem solving and their performance in problem solving? Significant positive correlations were found between each of the three attitude scores and each of the three problem solving scores reported for the students in the sample. Correlations ranged from .12 for the weakest relationship to .31 for the strongest relationship between attitude and performance. Though these correlations are not large, they are similar in size and range to those found by Lindgren et al. (1964) when comparing problem solving attitude and achievement in arithmetic with fourth grade children in Brazilian elementary schools. The rather stable positive correlations are also similar to those found between mathematics attitude and achievement with fourth grade students in the NLSMA X-population (see Crosswhite, 1972).

The differences in the relationship between attitudes and performance in problem solving for boys versus girls were also investigated. Once again, there was a significant positive relationship between attitude and performance for both boys and girls. For boys, the range of correlations was from .11 to .36; for girls, the range was from .12 to .24. Though the lowest correlations for both sexes were approximately the same, those for boys were consistently higher than those for girls. Thus, in this sample, there appeared to be a stronger relationship between problem solving attitude and problem solving performance for boys than for girls.

When correlations were calculated for the student data categorized by program-type, a positive relationship between problem solving attitude and performance was found for both groups. The correlations for the DMP sample ranged from .03 to .17, with six of the nine correlations between attitude and performance being significant. For the non-DMP sample, the correlations were somewhat higher, ranging from .18 to .43, with all correlations significant. Therefore, for the sample of the present study, there appeared to be a stronger relationship between student problem solving attitude and problem solving performance for the non-DMP sample than for the

DMP sample. Exploratory analyses with data from the DMP sample suggested that students with high problem solving performance have problem solving attitudes considerably higher than average, while those students with low performance have lower than average attitudes.

Question 5

The fifth question investigated in this study was: What is the relationship between fourth grade teachers' attitudes toward problem solving and their students' performance in problem solving? The correlations between teachers' attitudes and the mean problem solving performance of the students in their classes were found to be consistently very weak, negative, and non-significant, and in the range of -.05 to -.08. Thus, for the 30 fourth grade classes in the sample, there appeared to be little observable relationship between teacher problem solving attitude and student problem solving performance.

When the teacher attitude and student performance data were categorized by sex of the students, weak positive correlations were found between the two variables for girls; on the other hand, for the boys rather stable negative correlations were found. These opposite relationships were somewhat interesting, but none was statistically significant.

Surprising and almost unbelievable results were found when correlations were computed on the basis of program-type. For the non-DMP sample the correlations between teacher attitude and mean student problem solving performance ranged from .16 to .19 and were non-significant. However, for the DMP sample, rather substantial negative correlations were found; they ranged from -.47 to -.59, and two of the three calculated were significant at the .05 level. In an attempt to explain negative correlations of this proportion, several exploratory analyses were undertaken. Scatter plots were drawn to show the relationship between teacher attitude scores and mean student scores on each of the three parts of the problem solving test. The scatter plots and accompanying regression lines did, indeed, verify the negative nature of the relationships between teacher attitude and mean student performance. However, as noted previously in this chapter, correlations calculated on small sample sizes must be viewed with caution and are not necessarily indicative of those in the larger population. Since these correlations were based on a sample of 15 teachers, and since the attitudes of all teachers were favorable and the variance in scores was slight, it was concluded that additional research evidence from other fourth grade populations is needed before definitive judgments about the true relationships can be made.

Question 6

The sixth question of the study was as follows: Do fourth grade teachers' attitudes toward problem solving affect their students' problem solving performance, or is the effect of the opposite nature? The cross-lagged panel correlational technique recommended by Campbell and Stanley (1963) was used for this part of the study, since simple correlational procedures cannot answer questions of cause and effect.

Only the 15 DMP classes were involved in this part of the study. Since the correlation between student performance at Time 1 and teacher attitude at Time 2 was significantly more positive than the correlation between teacher attitude at Time 1 and student performance at Time 2, it was concluded that initial mean student problem solving performance had a greater effect on final teacher attitudes than initial teacher attitudes had on final mean student problem solving performance.

Cross-lagged panel correlations were also calculated for the data grouped by sex of students. The same directional relationships as in the total sample were noted for girls. However, for boys, this same directional relationship was apparent only for the comprehension and application parts of the problem solving test; for the problem solving part the differences in cross-lagged correlations were not significant. Therefore, the evidence was inconclusive for the boys in the sample.

As noted previously in this chapter, the relatively small sample size for this part of the study severely limits the extent to which the findings can be generalized to a larger population. Unfortunately, until verified by additional research evidence, the finding that student problem solving performance influenced teacher attitude more than teacher attitude influenced student performance must be viewed as merely suggestive. The findings regarding the directional relationships between teacher attitude and student performance for the boys and girls in the sample must be tempered by the same considerations.

Question 7

The second question for Part II and the seventh question investigated in the study was the following: Do fourth grade teachers' attitudes toward problem solving affect their students' attitudes toward problem solving or is the effect of the opposite nature? The cross-lagged panel correlational technique was also employed in an effort to answer this question. The correlations between teacher attitude at Time 1 and student attitude at Time 2 were significantly more positive than the correlations between teacher attitude at Time 2 and student attitude at Time 1. Thus, for the 15 DMP classes in this part of the study, initial teacher attitude seemed to have a greater efffect on final student attitude than initial student attitude had on final teacher attitude.

When the cross-lagged correlations were calculated on the data grouped by sex of student and the results analyzed, all differences in correlations were significant. Thus, the same directional relationships held between teacher attitude and student attitude for boys and girls separately as held for the total sample.

As was the case for Question 6, the small sample size for Part II of the study serves to limit the generalizability of the results. And so, the findings for Question 7 must also be viewed as suggestive of the relationships existing in the total population.

Concluding Remarks

This section of Chapter 7 has discussed the conclusions of the study in light of the findings of the investigation. A number of implications for mathematics education seem to evolve as a result of the conclusions. Some of these implications suggest the direction for future research studies. The implications of the study, along with recommendations for future research, are discussed in the next section of the chapter.

Implications of the Study and Recommendations for Future Research

The major purpose of this study was to investigate the relationships between selected noncognitive factors and the problem solving performance of fourth grade children. This type of information-oriented research is designed to provide insight into the nature of specific relationships between various curriculum variables and to suggest directions for additional research studies. This section of the chapter, then, discusses the implications and recommendations emanating from the present study.

Student Problem Solving Attitudes

Educators desire that students hold favorable attitudes toward all phases of the school program. If students in this study are reflective of those in a larger population, then most fourth grade students do, indeed, possess favorable attitudes toward problem solving. The attitudes of the students in the sample ranged from unfavorable to very favorable, with most students indicating favorable attitudes. Though not a random sample, the relatively large number of students in this study strengthens the generalizability of the findings.

The student problem solving attitude scale developed for this study seems to possess a high degree of internal consistency as measured by Cronbach's Alpha reliability coefficient. In addition, because of its careful development, the instrument seems to possess both content and face validity. However, at present, no other type of validity may be inferred. Therefore, the instrument needs further validation with other populations. The design of the instrument is such that is is suitable for use with students in the middle to upper elementary grades. The scale could be used in conjunction with other attitude scales such as CAPS (see Covington, 1966) to help establish the construct validity of the instrument.

An interesting follow-up to the present study would be an observational investigation to determine if students possess the kinds of problem solving behaviors which they claim to possess according to their responses on the problem solving attitude scale. The teachers of some students might also be interviewed to see if they observe the problem solving behaviors indicated by their students. Observational or interview results could be correlated with scores on the problem solving attitude scale as a means of determining the construct validity of the instrument.

If students in the sample for this study are representative of the larger population of fourth-grade students, there are apparently no differences in the problem solving attitudes of boys and girls at this level. Differing reactions to problem solving, then, may be based more on other individual student characteristics than on student sex.

Teacher Problem Solving Attitudes

All teachers in the sample for the study indicated favorable attitudes toward problem solving, but, because there were only 30 of them, their reactions may not be indicative of the population of fourth-grade teachers. Thus, the teacher problem solving attitude scale needs more extensive validation with other populations; additional evidence is needed to more firmly establish the internal consistency of the instrument. The instrument is designed so that it can be used with teachers from upper primary through middle school grades. It also holds promise for use with prospective elementary school teachers to determine their attitudes toward problem solving. A revision of the scale has received such use in a study dealing with the problem solving attitudes and performance of students in two elementary mathematics methods classes at the University of Wisconsin (Wearne & Whitaker, in preparation).

Student Problem Solving Performance

The findings of the present study would seem to indicate that fourth-grade students perform reasonably well on the first two parts of a test of mathematical problem solving which provides measures of comprehension, application, and problem solving.

However, most students did not perform well on the third part of the test which provides a measure of problem solving performance based upon the definition of problem as used in this study. Clearly, this test identifies those students who are not good at solving this type of mathematics problem. In this respect, the mathematical problem solving test developed by Romberg and Wearne (see Wearne, in preparation) is unique. Existing commercial instruments which purport to be problem solving tests are more like the application portion of this test. The commercial tests primarily involve one- or two-step problems and thus are not adequate measures of a student's ability to solve problems for which neither the solution nor method of solution is apparent.

It is the author's conviction that the test by Romberg and Wearne holds promise as a viable tool for providing a great deal of information to teachers and other school personnel regarding the problem solving capabilities of their students. This test can help teachers diagnose the difficulties which students are having in the areas of comprehension, application, and problem solving. Once problem areas are diagnosed, teachers can plan activities to remedy the difficulties. More extensive use of this type of problem solving test is relatively assured, as the test utilized in this study will serve as a model for the problem solving component of the DMP Terminal Accountability Tests (see Romberg, 1974).

The fact that there were no significant differences between the problem solving performance of boys and girls in this study would seem to indicate that teachers need not concern themselves with varying teaching techniques for the two sexes. However, the fact that the DMP sample of students performed significantly better than the non-DMP sample on the comprehension and application portions of the test suggests the existence of factors within the DMP program to produce this differential effect. The differential performance may be attributable to the underlying emphasis upon problem solving processes and skills that is characteristic of the DMP program. It would be interesting to determine whether significant differential effects exist in other populations of DMP and non-DMP students to whom the mathematical problem solving test is administered.

Student Problem Solving Attitudes and Performance

As noted earlier in this paper, previous research studies have suggested the existence of positive and rather stable relationships between student attitude and achievement in mathematics. These studies, however, have not examined the relationships between student attitude and performance in the area of problem solving. In this study, the significant and rather stable positive relationships found between student problem solving attitude and student problem solving performance suggest that the relationships between attitude and performance are the same for problem solving as they are for mathematics in general. Because of these positive relationships between problem solving attitude and performance, it would seem sagacious for teachers to continue their efforts to foster favorable student reactions and sentiments toward the many facets of mathematical problem solving.

Teacher Problem Solving Attitude As Related to Student Problem Solving Performance

The somewhat inconsistent findings of the study with regard to the relationships between teacher problem solving attitude and student problem solving performance, when coupled with the relatively small sample of classes upon which the findings were based, suggest the need for gathering similar data from other elementary school populations. This call for the collection of additional data is also based upon the rather surprising negative correlations that appeared in the DMP sample. Clearly, more research evidence is needed before definitive judgments can be made about the relationships between the problem solving attitudes of fourth grade teachers and the mathematical problem solving performance of their students.

Cause and Effect Relationships Between Teacher Attitude and Student Attitude and Performance

Though calls for replication of research studies are easily made, the findings of the second part of the study obviously demand that such occur. More evidence is required to ascertain whether the suggested relationships are indeed in the direction indicated. In the present study, initial student performance seemed to have a greater influence on final teacher attitudes than initial teacher attitudes had on final student performance. On the other hand, the direction of relationship seemed to be just the opposite for teacher attitude and student attitude; that is, initial teacher attitude had a greater effect on final student attitude than initial student attitude had on final teacher attitude. If the directional relationship is one way for teacher attitude and student performance, and in the opposite direction for teacher attitude and student attitude, then teachers should be aware of this situation. If this directional influence is dependent upon a particular population, then knowledge of that fact would also be beneficial.

The cross-lagged panel correlational technique (Campbell & Stanley, 1963) holds promise as a valuable research design for inferring the cause and effect relationships between such variables as attitude and performance. As a follow-up to the second part of the present investigation, the author would suggest that an improved plan for utilizing the cross-lagged technique might involve initial problem solving measures with students and teachers near the start of the school year and again at mid-year; this plan would reduce the confounding teacher-pupil influence which occurs when initial testing is done several weeks after the start of the school year. The sample size in this replicated study should be larger than that of the present study, and the "treatment" should, perhaps, be more rigidly controlled. If possible, the "experimental" classes should all study the same course content during the "treatment" period.

Concluding Remarks

The study reported in this paper was designed to investigate the relationships between selected noncognitive factors and the problem solving performance of fourth-grade children. Those factors selected for examination were student problem solving attitude, teacher problem solving attitude, and related sex and program-type differences. As is so often the case with research in the behavioral sciences, the findings of the study have, perhaps, raised more questions than they have answered. In the author's opinion, the most important findings of the study are those which suggested the following: (1) fourth-grade students and teachers seem to possess favorable attitudes toward mathematical problem solving; (2) fourth-grade students perform satisfactorily on the comprehension and application items, but not the "true" problem solving items of a three-part mathematical problem solving test; and (3) there seems to be a significant and stable positive relationship between student mathematical problem solving performance and student problem solving attitude. The other findings of the study are important, but must be viewed as suggestive and in need of additional research validation.

REFERENCES

Aiken, L. R. Biodata correlates of attitudes toward mathematics in three age and two sex groups. School Science and Mathematics, 1972, 72, 386-395.

Aiken, L. R. Affective factors in mathematics learning: Comments on a paper by Neale and a plan for research. Journal for Research in Mathematics Education, 1970, 1, 251-255.

Aiken, L. R. Attitudes toward mathematics. In J. W. Wilson and L. R. Carry (Eds.) Studies in mathematics, Volume XIX. Stanford, California: School Mathematics Study Group, 1969.

Aiken, L. R., & Dreger, R. M. The effect of attitudes on performance in mathematics. Journal of Educational Psychology, 1961, 52, 19-24.

Alexander, V. E. Seventh graders' ability to solve problems. School Science and Mathematics, 1960, 60, 603.

Allen, J., Learn, J., Schlater, J., & Wolfe, P. PICT1: Scatterplots, graphs, and tables. Madison: University of Wisconsin Academic Computing Center, 1976.

Allport, G. W. Attitudes. In M. Fishbein (Ed.) Readings in attitude theory and measurement. New York: John Wiley & Sons, 1967.

Anttonen, R. G. A longitudinal study in mathematics attitude. Journal of Educational Research, 1969, 62, 467-471.

Brown, E. D. Arithmetical understandings and attitudes toward arithmetic of experienced and inexperienced teachers (Doctoral dissertation, University of Nebraska, 1961). _Dissertation Abstracts_, 1962, _22_, 775.

Brownell, W. A. Problem solving. _The psychology of learning_. Forty-first Yearbook, Part II, NSSE. Chicago: University of Chicago Press, 1942.

Caezza, J. F. A study of teacher experience, knowledge of and attitude toward mathematics and the relationship of these variables to elementary school pupils' attitudes toward and achievement in mathematics (Doctoral dissertation, Syracuse University, 1969). _Dissertation Abstracts International_, 1970, _31_, 921A-922A.

Callahan, W. J. Adolescent attitudes toward mathematics. _Mathematics Teacher_, 1971, _64_, 751-755.

Campbell, D. T. The indirect assessment of social attitudes. _Psychological Bulletin_, 1950, _47_, 15-38.

Campbell, D. T., & Stanley, J. C. _Experimental and quasi-experimental designs for research_. Chicago: Rand McNally & Co., 1963.

Campbell, R. T., & Bohrnstedt, G. W. _ITEMPACK: An item analysis for Likert scales_. Madison: University of Wisconsin Academic Computing Center, 1975.

Carey, G. L. Sex differences in problem solving performance as a function of attitude differences. _Journal of Abnormal and Social Psychology_, 1958, _56_, 256-260.

Chase, C. I. The position of certain variables in the prediction of problem solving in arithmetic. Journal of Educational Research, 1960, 54, 14.

Chase, W. L. Subject preference of fifth grade children. Elementary School Journal, 1949, 50, 204-211.

Cleveland, G. A. A study of certain psychological and sociological characteristics as related to arithmetic achievement (Doctoral dissertation, Syracuse University, 1961). Dissertation Abstracts, 1962, 22, 2681-2682.

Cook, S. W., & Selltiz, C. A multiple-indicator approach to attitude measurement. Psychological Bulletin, 1964, 62, 36-55.

Cooper, J. B., & Pollock, D. The identification of prejudicial attitudes by the galvanic skin response. Journal of Social Psychology, 1959, 50, 241-245.

Corcoran, M., & Gibb, G. Appraising attitudes in the learning of mathematics. Evaluation in mathematics, Twenty-sixth Yearbook. National Council of Teachers of Mathematics. Washington: The Council, 1961.

Covington, M. V. A childhood attitude inventory for problem solving. Journal of Educational Measurement, 1966, 3, 234.

Covington, M. V., & Crutchfield, R. S. Facilitation of creative problem solving. Programmed Instruction, 1965, 4, 3-5.

Cronbach, L. J. Coefficient alpha and the internal structure of tests. Psychometrika, 1951, 16, 297-334.

Crosswhite, F. J. Correlates of attitudes toward mathematics. In J. W. Wilson, L. S. Cahen, & E. G. Begle (Eds.) NLSMA Reports No. 20. Stanford, California: School Mathematics Study Group, 1972.

Cureton, E. E. Corrected item-test correlations. Psychometrika, 1966, 31, 93-96.

Davis, G. A. Current status of research and theory in human problem solving. Psychological Bulletin, 1966, 66, 36-54.

Demars, R. J. A comparative study of seventh grade low achievers' attitudes and achievement in mathematics under two approaches, UICSM and traditional (Doctoral dissertation, University of Alabama, 1971). Dissertation Abstracts, 1972, 32, 4832A-4833A.

Dodson, J. W. Characteristics of successful insightful problem solvers. In J. W. Wilson & E. G. Begle (Eds.) NLSMA Report No. 31. Stanford, California: School Mathematics Study Group, 1972.

Dreger, R. M., & Aiken, L. R. The identification of number anxiety in a college population. Journal of Educational Psychology, 1957, 48, 344-351.

Dutton, W. H. Another look at attitudes of junior high pupils toward arithmetic. Elementary School Journal, 1968, 68, 265-368.

Dutton, W. H. Attitude change of prospective elementary school teachers toward arithmetic. Arithmetic Teacher, 1962, 9, 418-424.

Engelhart, M. D. The relative contribution of certain factors to individual differences in arithmetical problem solving ability. Journal of Experimental Education, 1932, 1, 19-27.

Erickson, L. H. Certain ability factors and their effect on arithmetic achievement. Arithmetic Teacher, 1958, 5, 287-293.

Evans, R. F. A study of the reliabilities of four arithmetic scales and an investigation of component mathematics attitudes (Doctoral dissertation, Case Western Reserve University, 1971). Dissertation Abstracts International, 1972, 32, 3086A-2087A.

Farr, R. S. Personality variables and problem solving performance: An investigation of the relationships between field dependence-independence, sex-role identification, problem difficulty and problem-solving performance (Doctoral dissertation, New York University, 1968). Dissertation Abstracts, 1969, 29, 2562A.

Faust, C. E. A study of the relationship between attitude and achievement in selected elementary school subjects (Doctoral dissertation, State University of Iowa, 1963). Dissertation Abstracts, 1963, 23, 2752-2753.

Fedon, J. P. The role of attitude in learning arithmetic. Arithmetic Teacher, 1958, 5, 304-310.

Fletcher, H. Possible difficulties in interpreting statistical analyses using group means as the experimental unit. Technical Memo No. 68-1. Madison: Wisconsin Research and Development Center for Cognitive Learning, 1968.

Fennema, E. Mathematics learning and the sexes: A review. Journal for Research in Mathematics Education, 1974, 5, 126-139.

Gagné, R. M. Human problem solving: Internal and external events. In B. Kleinmuntz (Ed.) Problem solving: Research, method, and theory. New York: John Wiley & Sons, 1966.

Garner, M. V. A study of the educational backgrounds and attitudes of teachers toward algebra as related to the attitudes and achievements of their Anglo-American and Latin-American pupils in first year algebra classes of Texas (Doctoral dissertation, North Texas State University, 1963). Dissertation Abstracts, 1964, 24, 189.

Gee, B. C. Attitudes toward mathematics and basic mathematical understanding of prospective elementary school teachers at Brigham Young University (Doctoral dissertation, Oregon State University, 1966). Dissertation Abstracts, 1966, 26, 6528.

Hadamard, J. The psychology of invention in the mathematical field. New York: Dover Publications, 1945.

Hansen, C. W. Factors associated with successful achievement in problem solving in sixth grade arithmetic. Journal of Educational Research, 1944, 38, 14.

Harootunian, B., & Tate, M. W. The relationship of certain selected variables to problem-solving ability. Journal of Educational Psychology, 1960, 51, 326-333.

Hayes, W. L. Statistics for the behavioral sciences. New York: Holt, Rinehart, & Winston, 1973.

Hilton, T. L., & Berglund, G. W. Sex differences in mathematics achievement: A longitudinal study. Journal of Educational Research, 1974, 67, 231-237.

Hungerman, A. D. Achievement and attitude of sixth grade pupils in conventional and contemporary mathematics programs. Arithmetic Teacher, 1967, 14, 30-39.

Hurst, D. The relationship between certain teacher-related variables and student achievement in third grade arithmetic (Doctoral dissertation, Oklahoma State University, 1967). Dissertation Abstracts, 1968, 28, 4935-36.

Husén, T. International study of achievement in mathematics, Volumes I & II. New York: John Wiley & Sons, 1967.

Johnson, S. C. Hierarchical clustering schemes. Psychometrika, 1967, 32, 241-254.

Jonsson, H. A. Interaction of test anxiety and test difficulty in mathematics problem solving performance (Doctoral dissertation, University of California, Berkeley, 1965). Dissertation Abstracts, 1966, 26, 3757.

Karas, S. F. A study of personality and socio-economic factors and mathematics achievement (Doctoral dissertation, Columbia University, 1964). Dissertation Abstracts, 1968, 28, 5191B-5192B.

Katz, D. The functional approach to the study of attitudes. In M. Fishbein (Ed.) Readings in attitude theory and measurement. New York: John Wiley & Sons, 1967.

Keller, W. R. The relative contributions of certain factors to individual differences in the algebraic problem-solving ability. Journal of Experimental Education, 1939, 8, 34.

Kilpatrick, J. Problem solving and creative behavior in mathematics. In J. W. Wilson & L. R. Carry (Eds.) Studies in mathematics, Volume XIX. Stanford, California: School Mathematics Study Group, 1969.

Kilpatrick, J. Analyzing the solution of word problems in mathematics: An exploratory study (Doctoral dissertation, Stanford University, 1967). Dissertation Abstracts, 1968, 28, 4380A.

Klausmeier, H. J., Quilling, M. R., Sorenson, J. S., Way, R. S., & Glasrud, G. R. Individually guided education and the multiunit school. Madison: Wisconsin Research and Development Center for Cognitive Learning, 1971.

Kleinmuntz, B. (Ed.). Problem solving: Research, method, and theory. New York: John Wiley & Sons, 1966.

Leonhardt, E. A. An analysis of selected factors in relation to high and low achievement in mathematics (Doctoral dissertation, University of Nebraska, 1962). Dissertation Abstracts, 1963. 23, 3869.

Likert, R. A technique for the measurement of attitudes. Archives of Psychology, 1932, No. 140, 44-53.

Lindgren, H. C., Silva, I., Faraco, I., & DaRocha, N. S. Attitudes toward problem solving as a function of success in arithmetic in Brazilian elementary schools. Journal of Educational Research, 1964, 58, 44-45.

Loomer, N. J. *A multidimensional exploratory investigation of small group-heuristic and expository learning in calculus*. Unpublished doctoral dissertation, University of Wisconsin-Madison, 1976.

Lowry, W. C. Reaction paper. *Journal of Research and Development in Education*, 1967, *1*, 119.

Lucas, J. F. *An exploratory study in the diagnostic teaching of heuristic problem solving strategies in calculus*. Unpublished doctoral dissertation, University of Wisconsin-Madison, 1972.

Lyda, W. J., & Duncan, F. M. Quantitative vocabulary and problem solving. *Arithmetic Teacher*, 1967, *14*, 291.

Maguire, T. O. Evaluation of the IPI project. *Alberta Journal of Educational Research*, 1971, *17*, 255-273.

Mastantuono, A. K. An examination of four arithmetic attitude scales (Doctoral dissertation, Case Western Reserve University, 1970). *Dissertation Abstracts*, 1971, *32*, 248A.

May, D. C. An investigation of the relationship between selected personality characteristics of eighth-grade students and their achievement in mathematics (Doctoral dissertation, University of Florida, 1971). *Dissertation Abstracts International*, 1972, *33*, 555A.

Meyer, R. A. *A study of the relationship of mathematical problem solving performance and intellectual abilities of fourth grade children*. Technical Report No. 379. Madison: Wisconsin Research and Development Center for Cognitive Learning, 1976.

Montgomery, M. E., & Whitaker, D. R. Report of the coordinators' training for large scale field testing of Developing Mathematical Processes. Technical Report No. 296. Madison: Wisconsin Research and Development Center for Cognitive Learning, 1975.

Moore, B. D. The relationship of fifth-grade students' self-concepts and attitudes toward mathematics to academic achievement in arithmetical computation, concepts, and application (Doctoral dissertation, North Texas State University, 1971). Dissertation Abstracts International, 1972, 32, 4426A.

Morton, R. L. Factors affecting the ability of pupils to solve verbal problems in arithmetic (Doctoral dissertation, Ohio State University, 1925). Dissertation Abstracts, 1928L, 82.

Naylor, F. D., & Gaudry, E. The relationship of adjustment, anxiety, and intelligence to mathematics performance. Journal of Educational Research, 1973, 66, 413-417.

Neale, D. C. The role of attitudes in learning mathematics. Arithmetic Teacher, 1969, 16, 631-640.

Neill, R. D. The effects of selected teacher variables on the mathematics achievement of academically talented junior high school pupils (Doctoral dissertation, Columbia University, 1966). Dissertation Abstracts, 1967, 27, 997.

Neufeld, K. A. Differences in personality characteristics between groups having high and low mathematical achievement gain under individualized instruction (Doctoral dissertation, University of Wisconsin, 1967). Dissertation Abstracts, 1968, 28, 4540A.

Nunnally, J. C. Psychometric theory. New York: McGraw-Hill, 1967.

The Ontario Institute for Studies in Education. K-13 mathematics, some non-geometric aspects, Part II: Computing, logic, and problem solving. Toronto: The Institute, 1967.

Osborn, K. H. A longitudinal study of achievement in and attitude toward mathematics of selected students using SMSG materials (Doctoral dissertation, University of California, Berkeley, 1965). Dissertation Abstracts, 1966, 26, 7119.

Osgood, C. E., Suci, G. J., & Tannenbaum, P. H. The measurement of meaning. Urbana, Illinois: University of Illinois Press, 1957.

Phelps, J. A study comparing attitudes toward mathematics of SMSG and traditional elementary school students (Doctoral dissertation, Oklahoma State University, 1963). Dissertation Abstracts, 1965, 25, 1052.

Phillips, R. B. Teacher attitude as related to student attitude and achievement in elementary school mathematics. School Science and Mathematics, 1973, 73, 501-507.

Poffenberger, T. Research note on father-child relations and father viewed as negative figure. Child Development, 1959, 30, 489-492.

Poffenberger, T., & Norton, D. A. Factors in the formation of attitudes towards mathematics. Journal of Educational Research, 1959, 52, 171-176.

Polya, G. Mathematical discovery, Volume II. New York: John Wiley & Sons, 1965.

Polya, G. How to solve it. Princeton, New Jersey: Princeton University Press, 1943.

Reese, H. W. Manifest anxiety and achievement test performance. Journal of Educational Psychology, 1961, 52, 132-135.

Reys, R. E., & Delon, F. G. Attitudes of prospective elementary school teachers towards arithmetic. Arithmetic Teacher, 1968, 15, 363-366.

Riedesel, A. C. Problem solving: Some suggestions from research. Arithmetic Teacher, 1969, 16, 54-58.

Romberg, T. A. Specifications for terminal accountabiltiy tests for DMP. Project Paper No. 74-1. Madison: Wisconsin Research and Development Center for Cognitive Learning, 1974.

Romberg, T. A., & DeVault, M. V. Mathematics curriculum: Needed research. Journal of Research and Development in Education, 1967, 1, 95-112.

Romberg, T. A., Harvey, J. G., & Moser, J. M. Developing mathematical processes. Chicago: Rand McNally & Co., 1974, 1975, 1976.

Romberg, T. A., Harvey, J. G., & Moser, J. M. Developing mathematical processes resource manual, topics 41-65. Chicago: Rand McNally & Co., 1974.

Romberg, T. A., & Wearne, D. C. Romberg-Wearne mathematical problem solving test. Madison: Wisconsin Research and Development Center for Cognitive Learning, 1976.

Romberg, T. A., & Wilson, J. W. The development of tests. J. W. Wilson, L. S. Cahen, & E. G. Begle (Eds.) NLSMA Reports No. 7. Stanford, California: School Mathematics Study Group, 1969.

Rosenberg, M. J., Hovland, C. I., McGuire, W. J., Abelson, R. P., & Brehm, J. W. Attitude organization and change. New Haven, Conn.: Yale University Press, 1960.

Sax, G. Principles of educational measurement and evaluation. Belmont, California: Wadsworth Publishing Company, 1974.

Scandura, J. M. Research in mathematics education--an overview and a perspective. Research in mathematics education. Washington: The National Council of Teachers of Mathematics, 1967.

Schonberger, A. K. The interrelationship of sex, visual spatial abilities, and mathematical problem solving ability in grade seven. Technical Report No. 387. Madison: Wisconsin Research and Development Center for Cognitive Learning, 1976.

Scott, W. A. Attitude measurement. In G. Lindzey & E. Aronson (Eds.) The handbook of social psychology, second edition. Reading, Massachusetts: Addison-Wesley, 1968.

Shapiro, E. W. Attitudes toward arithmetic among public school children in the intermediate grades (Doctoral dissertation, University of Denver, 1961). Dissertation Abstracts, 1962, 22, 3927-3928.

Sheehan, T. J. Patterns of sex differences in learning mathematical problem solving. The Journal of Experimental Education, 1968, 36, 86.

Stern, G. C. Measuring noncognitive variables in research on teaching. In N. L. Gage (Ed.) Handbook of research on teaching. Chicago: Rand McNally & Co., 1963.

Stright, V. M. A study of the attitudes toward arithmetic of students and teachers in the third, fourth, and sixth grades. Arithmetic Teacher, 1960, 7, 280-286.

Suppes, P. The case for information-oriented (basic) research in mathematics education. Research in mathematics Education. Washington: The National Council of Teachers of Mathematics, 1967.

Suydam, M. N. An evaluation of journal-published research reports on elementary school mathematics: 1900-1965 (Doctoral dissertation, Pennsylvania State University, 1966). Dissertation Abstracts, 1967, 27, 3563.

Suydam, M. N., & Weaver, J. F. Research on mathematics education (K-12) recorded in 1974. Journal for Research in Mathematics Education, 1975, 6, 253-282.

Suydam, M. N., & Weaver, J. F. Research on mathematics education (K-12) reported in 1973. Journal for Research in Mathematics Education, 1974, 5, 238-272.

Suydam, M. N., & Weaver, J. F. Research on mathematics education (K-12) reported in 1972. Journal for Research in Mathematics Education, 1973, 4, 205-242.

Suydam, M. N., & Weaver, J. F. Research on mathematics education (K-12) reported in 1971. Journal for Research in Mathematics Education, 1972, 3, 196-232.

Suydam, M. N., & Weaver, J. F. Research on mathematics education (K-12) reported in 1970. Journal for Research in Mathematics Education, 1971, 2, 257-298.

Swafford, J. O. A study of the relationship between personality and achievement in mathematics (Doctoral dissertation, University of Georgia, 1969). Dissertation Abstracts International, 1970, 30, 5353A.

Thomas, W. I., & Znaniecki, G. The Polish peasant in Europe and America. Boston: Badger Press, 1918.

Thurstone, L. L. Attitudes can be measured. American Journal of Sociology, 1928, 33, 529-554.

Todd, R. M. A mathematics course for elementary teachers: Does it improve understanding and attitudes? Arithmetic Teacher, 1966, 13, 198-202.

Torrance, E. P. Characteristics of mathematics teachers that affect students' learning. Report No. CRP-1020. Washington: U. S. Office of Education, 1966.

Treacy, J. P. Relationship of reading skills to the ability to solve arithmetic problems. *Journal of Educational Research*, 1944, *38*, 86-96.

Van de Walle, J. A. Attitudes and perceptions of elementary mathematics possessed by third and sixth grade teachers as related to student attitude and achievement in mathematics (Doctoral dissertation, The Ohio State University, 1972). *Dissertation Abstracts International*, 1973, *33*, 4254A-4255A.

Wagner, R. V. The study of attitude change: An introduction. In R. W. Wagner & J. J. Sherwood (Eds.) *The study of attitude change*. Belmont, California: Brooks/Cole Publishing Co., 1969.

Wearne, D. C. Development of a test of mathematical problem solving which yields a comprehension, application, and problem solving score. Doctoral dissertation, University of Wisconsin-Madison, in preparation.

Wearne, D. C., & Whitaker, D. R. *The effect of mathematics methods courses on the problem solving attitudes and performance of preservice elementary school teachers*. In preparation.

Wess, R. G. An analysis of the relationship of teachers' attitudes as compared to pupils' attitudes and achievement in mathematics (Doctoral dissertation, University of South Dakota, 1969). *Dissertation Abstracts International*, 1970, *30*, 3844A-3845A.

Wetterstrand, W. H., Learn, J., & Wolfe, P. *DSTAT2: Descriptive statistics and correlation*. Madison: University of Wisconsin Academic Computing Center, 1973.

White, M. J. A. A study of the change of achievement and attitude toward arithmetic by prospective elementary school teachers under the conditions of television (Doctoral dissertation, Wayne State University, 1963). Dissertation Abstracts, 1965, 25, 2302-2303.

Wickes, H. E. Pre-service mathematics preparation of elementary teachers: The relative effectiveness of two programs in determining attitudes toward and achievement in mathematics (Doctoral dissertation, Colorado State College, 1967). Dissertation Abstracts, 1968, 28, 2591A.

Wilson, J. W., Cahen, L. S., & Begle, E. G. (Eds.). Non-test data. NLSMA Reports No. 9. Stanford, California: School Mathematics Study Group, 1968.

Woodall, P. G. A study of pupils' achievements and attitudes in the SMSG and the traditional mathematics programs of the Lewiston School District, 1960-1965 (Doctoral dissertation, University of Idaho, 1966). Dissertation Abstracts, 1967, 27, 4040B-4041B.

Wozencraft, M. Are boys better than girls in arithmetic? Arithmetic Teacher, 1963, 10, 486-490.

Zalewski, D. L. An exploratory study to compare two performance measures: An interview-coding scheme of mathematical problem solving and a written test. Technical Report No. 306. Madison: Wisconsin Research and Development Center for Cognitive Learning, 1974.

APPENDIX A

Developing Mathematical Processes

Topics 1 - 65

Report from the Project on

ANALYSIS OF MATHEMATICS INSTRUCTION

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TOPICS 1 - 64 DESCRIPTIONS

TOPIC 1 Describing and Classifying

The children describe and classify familiar objects. Likenesses and differences are stressed and the skill of sorting is introduced.

TOPIC 2 Comparing and Ordering on Length

Real objects are directly compared and then ordered on length. The children determine whether two objects are the same length and if not, they determine which is longer.

TOPIC 3 Equalizing on Length

After comparing and ordering two objects or pictures of objects on length, the children make them equal in length by adding on to the shorter or taking away from the longer.

TOPIC 4 Ordering More than Two Objects on Length

The children put more than two objects in order from shortest to longest or from longest to shortest.

TOPIC 5 Representing Length

In situations in which the children cannot compare and order lengths directly, they physically represent the lengths and compare and order the representations to decide about the original objects.

TOPIC 6 Movement and Direction

The children learn that a path is a representation of a movement in some direction. Simple direction words are used.

TOPIC 7 Comparing, Ordering, and Equalizing on Numerousness

The children compare, order, and equalize sets on the attribute of numerousness. One-to-one matching is emphasized. Numbers and counting are not included.

TOPIC 8 Three Dimensional Shape

The children describe and classify three-dimensional objects on the attribute of numerousness.

TOPIC 9 Representing Numerousness Physically

The children use objects to physically represent numerousness in situations in which direct comparing and ordering are impossible. Then they compare, order, and equalize the representations to decide about the original sets.

TOPIC 10 Paths and Location

The children work with locating objects. Paths are used as references.

TOPIC 11 Representing Numerousness Pictorially

The children pictorially represent the numerousness of sets by graphing. Graphing serves as a transition between physically representing numerousness and symbolically representing numerousness.

TOPIC 12 Tallying

The children learn tallying which serves as a transition between pictorially representing numerousness (graphing) and symbolically representing numerousness (numbers).

TOPIC 13 Time

The children compare and order events on time of duration and time of occurrence.

TOPIC 14 Representing Numerousness Symbolically

Numerousness is represented symbolically by the number words and the number symbols. The children learn to count and to recognize the symbols. They do not learn to write the number symbols at this time.

TOPIC 15 Two Dimensional Shape

The children describe and classify regions including faces of solids on the attribute of shape.

TOPIC 16 Comparing and Ordering on Weight

The children compare and order real objects on the attribute of weight by using balances.

TOPIC 17 Writing Numbers

The children learn to write the numbers 0-10 and practice writing them in a variety of situations.

TOPIC 18 Comparing and Ordering Events on Time

The children compare and order events on time of duration and time of occurrence.

TOPIC 19 Assigning Measurements

The children use arbitrary units to represent lengths or weights of objects by assigning a number and unit. Then they compare and order objects using these measurements.

TOPIC 20 Paths

The children describe a closed path such as a triangle, rectangle, and square in terms of number and length of sides. They are introduced to the use of the geoboard as a simple way to make paths.

TOPIC 21 Comparison Sentences

The relationship between two sets or two objects on a given attribute is represented by a sentence involving = or ≠ (for example: 5 ≠ 7, 6 = 6, A ≠ B). The process of validating is introduced.

TOPIC 22 Comparing and Ordering on Capacity

The children directly compare and order the capacities of containers by pouring from one to another. Also they learn to represent the capacity of a given container by assigning a measurement with arbitrary units.

TOPIC 23 Order Sentences

The order relationship between two sets or two objects on a given attribute is examined further. Now if the two are not equal, the children decide which is larger and write an order sentence (for example: 5 < 7, 6 = 6, A > B). The children also learn to validate given order sentences.

TOPIC 24 The Number 0-20

The numbers 11-20 are introduced as representing the numerousness of sets. The children learn to recognize and write these numbers and to count such sets. The numbers 0-10 are reviewed.

TOPIC 25 Representing Equalizing Situations

The children learn to represent the process of equalizing by writing a sentence about how two sets or objects have been or will be equalized.

TOPIC 26 Movement and Direction

Simple maps are examined. The children follow simple oral or written instructions involving movement on a given path or between given points. They also learn to give such instructions.

TOPIC 27 Representing other Equalizing Situations

The children look at other equalizing situations in which one of the two sets to be equalized is unknown. They represent these situations with sentences such as $\boxed{} - 2 = 4$, $5 = \boxed{} + 3$, $2 + 6 = \boxed{}$, $\boxed{} = 10 - 3$. They also begin to solve sentences. The process of validating is stressed.

TOPIC 28 Symmetry, Fractions and Shape

The children learn that some familiar figures are symmetric and told to test whether or not a given figure is symmetric. Fractions (halves, thirds, etc.) are introduced in terms of the attribute of area.

TOPIC 29 Representing Joining and Separating

The process of joining and separating are introduced and represented by sentences. Active adding on and taking away are stressed. The children also solve such sentences.

TOPIC 30 Grouping

The children learn to separate any set by grouping the objects of the set into subsets of a given size. Then they record the results of their grouping. After grouping a set by 3, they might record 5(3) + 2.

TOPIC 31 Geometric Shapes

A variety of geometric ideas are reviewed and explored here with many types of materials.

TOPIC 32 Solving Number Sentences (0-10)

Other types of joining and separating situations are examined, and sentences are written to represent them. The children solve any given open sentence with numbers 0-10 and validate it. Number facts receive attention.

TOPIC 33 The Numbers 0-99

The numbers 21-99 are introduced as representing the numerousness of sets. The children learn to recognize and write these numbers in expanded 3(10) + 4 and compact (34) notation. Place value is introduced.

TOPIC 34 Units of Capacity

Standard units of capacity (cup, quart, and gallon) are introduced. Capacities of various containers are represented, compared, and ordered in terms of these standard units.

TOPIC 35 Number Sentences (0-20)

Open sentences involving the numbers 11-20 are solved and validated. Number facts are emphasized.

TOPIC 36 Describing, Classifying, and Locating

The children sort objects on the basis of two or more attributes and are introduced to the intersection of sets. They locate objects in relation to paths. They look at grids as intersections of columns and rows.

TOPIC 37 Partitioning

The children learn to divide a set into a given number of equal subsets and a remainder, and they write the results in grouping notation. Then they apply this knowledge to fractions and divide various sets into halves, thirds, etc.

TOPIC 38 Number Sentences (0-99)

A variety of situations involving the numbers 0-99 are represented by sentences. The children solve open sentences about joining, separating, and differences using objects or pictures. The regrouping that occurs when the children are solving these problems is focused on as a background for the algorithm topic (Topic 40).

TOPIC 39 Units of Length

Standard units of length (inches, feet, yards, centimeters, and meters) are introduced. The children measure various lengths using these units and compare and order the measurements.

TOPIC 40 The Addition and Subtraction Algorithms (0-99)

Addition and subtraction algorithms for two-digit numbers with and without regrouping are introduced. The children use their background with regrouping objects in Topic 38 to give meaning to the algorithms.

TOPIC 41 Movement and Direction

The children look at, describe, and make physical movements along labeled paths and grids. This serves as a background for later work with integers.

TOPIC 42 Units of Weight

Standard units of weight, ounces and pounds, are introduced. The children represent various weights using these units and they compare, order, add, and subtract these measurements. The children investigate ordering fractional parts of weights.

TOPIC 43 Solving Open Sentences

A variety of open situations are examined. The children represent a way of solving the problem with an open sentence and then solve it. They investigate the effect on an order relationship of changing the sets or objects described in an order sentence. The children choose and write fractions which represent parts of objects or of sets.

TOPIC 44 Angles and Symmetry

Angles associated with objects or figures are directly compared and ordered. Emphasis is placed on right angles. The children explore symmetry further by using mirrors.

TOPIC 45 The Numbers 0-999

The numbers 100-999 are introduced; place value is stressed through grouping. Both the expanded notation (3(100) + 5(10) + 7) and the compact notation (357) are used.

TOPIC 46 Comparing and Ordering Areas

The children use arbitrary units of area to measure regions. Then they compare and order objects using these measurements. Fractional parts of areas are also considered.

TOPIC 47 Grouping and Partitioning

The children represent a grouping or partitioning problem with an open sentence. They then solve the sentence physically, pictorially, or symbolically. Repeated addition and subtraction are stressed.

TOPIC 48 Geometric Figures

Various basic geometric attributes of figures are examined and described by the children as they experiment with a variety of materials.

TOPIC 49 Solving Addition and Subtraction Problems 0-999

The addition and subtraction algorithms are extended to three-digit numbers. The children continue to represent a fractional part of a set or of an object by writing a fraction and to represent a fraction with fractional parts of sets or objects.

TOPIC 50 Measuring Length

Measuring lengths with standard units is continued; more emphasis is placed on precise measurements as the children consider fractional parts of units and millimeters.

TOPIC 51 Measuring Time

The children use arbitrary and standard units to measure durations. Then they compare and order durations using these measurements.

TOPIC 52 Investigating Problems

Problems that require a combination of familiar processes are presented. The children are asked to evaluate information presented in a problem situation in terms of whether that information is sufficient for, or relevant to the solution of the problem. The children are expected to master solving addition and subtraction problems with 3-digit numbers.

TOPIC 53 Location and Angles

The children describe the location of objects on a grid with coordinates and located objects on a grid given the coordinates. They also represent angles physically and pictorially to compare, order, or join them or to conduct experiments.

TOPIC 54 Grouping and Partitioning Sentences

The children write open sentences to represent grouping and partitioning situations. They then solve the sentences symbolically using repeated addition and subtraction. Use of methods to shorten the steps needed to solve, including efficient repeated addition or subtraction and shortcuts involving commutativity is extended to sentences with larger numbers.

TOPIC 55 Representing Common Fractions

The children decide whether a given fraction correctly represents a given fractional part of a whole length, region, or set. They also show that they know what a fraction means by drawing a picture of it.

TOPIC 56 Describing Three-Dimensional Objects

The children take another look at attributes of objects, with special emphasis on volume, capacity, faces, and edges. They continue to compare and order objects on these attributes.

TOPIC 57 The Numbers 0-999,999

Thousands, ten-thousands, and hundred thousands are introduced with objects and pictures; grouping by ten as the key to place value is emphasized. Addition and subtraction of 4-digit numbers are included, but mastery is not expected.

TOPIC 58 Units of Area

Standard metric and English square units are introduced; the children measure the dimensions of rectangular regions and draw a picture to help them find the area of the region. They think of the area as an array of square units.

TOPIC 59 Ordering Fractions With Representations

After the children have ordered fractional parts of given pictures or objects, they order fractions such as 3/4 and 5/8 by drawing pictures, especially arrays.

TOPIC 60 Multiplication and Division Sentences

The children represent grouping and partitioning situations with multiplication or division open sentences. They master the basic multiplication facts. Some of the background for the multiplication and division algorithms is included.

TOPIC 61 Geometric Figures

The children continue to describe geometric figures with special emphasis on parallel and perpendicular lines. Many geometric concepts are approached intuitively as the children experiment with paper-folding, geoboards, geometric pieces, and other materials.

TOPIC 62 Addition and Subtraction of Larger Numbers

The addition and subtraction algorithms are extended to five- and six-digit numbers and the children are expected to master the algorithm for the numbers 0-999,999.

TOPIC 63 Measuring

Children measure objects on many attributes to solve problems involving ordering, joining and separating. Special emphasis is plcaed on converting from one unit to another by grouping or partitioning. The children conduct open-ended experiments, collect and organize their data, and discuss the results.

TOPIC 64 Multiplication With Larger Numbers

The background for the multiplication algorithm continues to be developed as the children draw pictures of subproducts to help solve multiplication problems. More efficient ways of solving division sentences are developed.

TOPIC 65 Problem Solving

Problems that require a combination of familiar processes are presented. Grouping and partitioning are emphasized. The children are asked to evaluate information presented in a problem situation in terms of whether that information is sufficient for, or relevant to, the solution of the problem.

APPENDIX B

MATHEMATICAL PROBLEM SOLVING TESTS

NAME ____________________

MATH TEACHER ____________________

BOY __________

GIRL __________

ROMBERG-WEARNE

MATHEMATICAL PROBLEM SOLVING TEST

(Time 1)

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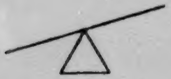
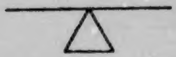
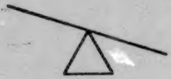
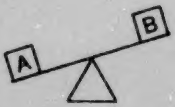
Center Contract No. NE-C-00-3-0065

Circle the picture that shows the balance beam in balance.



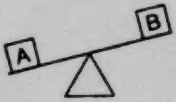
Circle the sentence that tells about the weights $\boxed{A}$ and $\boxed{B}$.

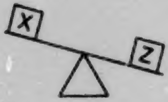
$\boxed{A}$ weighs less than $\boxed{B}$.

$\boxed{A}$ weighs more than $\boxed{B}$.

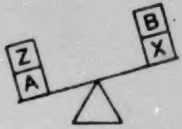
$\boxed{A}$ weighs the same as $\boxed{B}$.

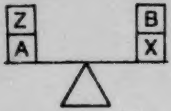
impossible to tell from the picture

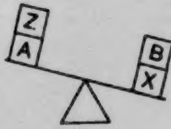




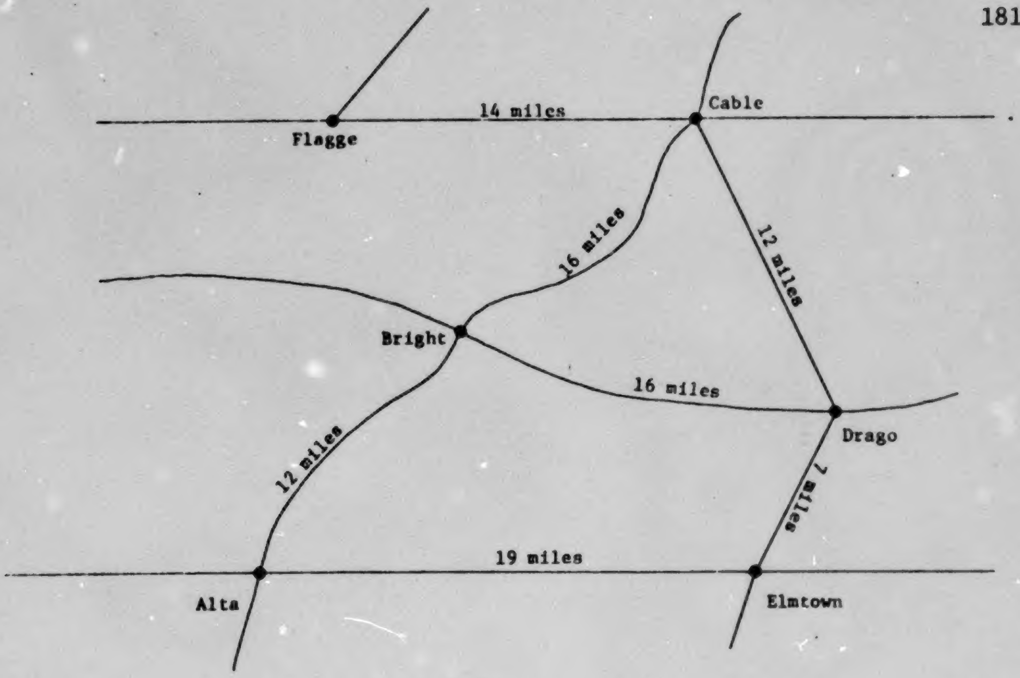
Weights $\boxed{A}$ and $\boxed{Z}$ are put together on one end of the balance beam and $\boxed{B}$ and $\boxed{X}$ are put together on the other end of the balance beam. Circle the picture that shows how the balance beam might look.







impossible
to tell


14 miles
Cable
Flagge
16 miles
12 miles
Bright
16 miles
Drago
12 miles
7 miles
19 miles
Alta
Elmtown

The distance from Alta to Bright is:
- 7 miles
- 12 miles
- 16 miles
- 19 miles

The shortest distance from Alta to Drago is:
- through Bright
- through Cable
- through Elmtown
- through Flagge

The sign

BRIGHT 16
ELMTOWN 19

should be placed:
- in Drago
- in Alta
- in Flagge
- in Cable

Jack and Bob went fishing. They both caught two kinds of fish, trout and pike. Bob caught 10 trout. Together they caught 18 trout and 10 pike. Jack caught 15 fish.

How many trout did Bob catch? ______________

How many fish did they catch altogether? ______________

How many pike did Bob catch? ______________

There are 45 houses on Century Avenue. The houses are white, blue, yellow, green, or gray. 18 of the houses are white. There are half as many blue houses as white houses. 15 of the houses are yellow. Only 1 house is gray.

There are more blue houses than white houses. TRUE FALSE Impossible to tell

There are more blue houses than yellow houses. TRUE FALSE Impossible to tell

How many of the houses are green? ______________

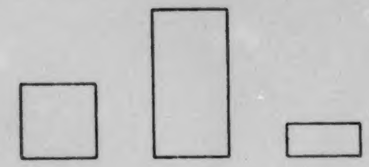
Put a circle around the sentence that tells about A < B.

A is less than B.

A is greater than B.

A is equal to B.

The sentences tell about the figures. Decide which figure is A, which is B, and which is C. Write the letters on the figures.



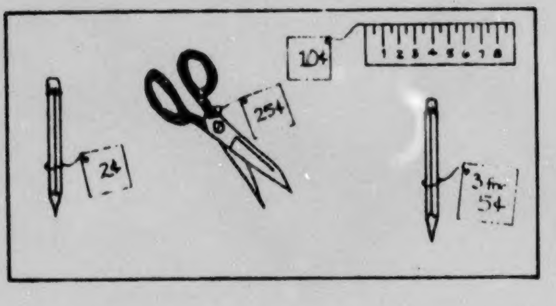
A < B B < C

The following sentences tell about the numbers A, B, C, and D.

$$C + 3 = B$$
$$D < A$$
$$B = D - 4$$

Write the four numbers A, B, C, and D in order from smallest to largest.

________, ________, ________, ________
(smallest)



Both pencils cost the same. TRUE FALSE IMPOSSIBLE TO TELL

How much would 8 of the 2¢ pencils cost? ______________

What is the greatest number of pencils you could buy for 27¢? ______________

Jack lost some weight. Susan lost half as much weight as Jack lost. Carol lost half as much weight as Susan lost. Carol lost 10 pounds.

Jack lost more weight than Susan. TURE FALSE IMPOSSIBLE TO TELL

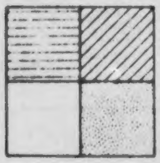
Circle the number that tells how many pounds Susan lost.

$2\frac{1}{2}$ 5 10 20 40 none of these

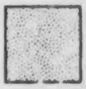
If Jack weighs 130 pounds now, how much did he weigh before he lost weight?

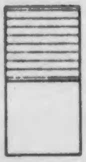
____

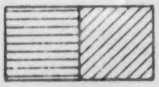
Each of the four blocks ▤, ▨, □, ░ in the picture is covering a number of chips.

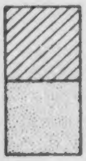


The numbers below the pictures tell how many chips are covered by those blocks.


2

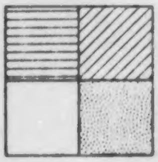

8


10


9

How many chips are covered by ░ ? ______________

How many chips are covered by



? ______________

How many chips are covered by □ ? ______________

Jackie has twice as many football cards as Mike. Each has more football cards than Terry. Mike has 15 football cards.

Terry has the most football cards. TRUE FALSE

How many football cards does Jackie have? _______________

Circle the number that tells how many football cards the three could have altogether. (You don't know exactly how many they have altogether.)

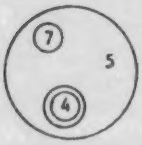
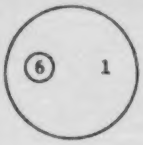
63 42 58 72

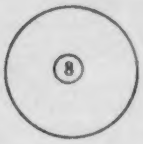
A parking lot has room for 8 rows of cars with 9 cars parked in each of those rows.

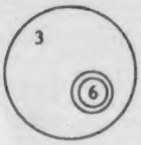
The parking lot has the same
number of cars in each of the 8 rows. TRUE FALSE

How many cars can be parked in the parking lot? _______________

In another parking lot, trucks are parked. Each truck takes the space of 3 cars. There are 12 trucks in the parking lot and it is completely full. If there were 4 rows in the parking lot, how many cars could be parked in each row? _______________

In Circleland, people write  when they mean 475 and they write  when they mean 61.

In Circleland, people write  when they mean 8. TRUE FALSE

What do they mean when they write ?

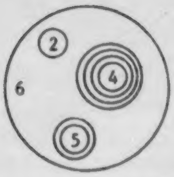
36

63

630

603

306

What do they mean when they write ?

4,526

40,526

4,562

45,620

45,260

Everything weighs 6 times as much on Earth as it does on the Moon.

Everything weighs 2 times as much on Earth as it does on Mars.

A box weighs more on the Moon than it does on Earth.

TRUE FALSE IMPOSSIBLE TO TELL

A box weighs 24 pounds on the Moon. How much does it weigh on Earth?

$\frac{1}{6}$ 4 6 24 144 impossible to tell

A dog called Rover weighs 4 pounds on the Moon.

Another dog called Spot weighs 12 pounds on Mars.

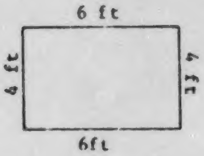
If both dogs were in the same place, then

Rover would weigh more than Spot

Rover would weigh less than Spot

Rover would weigh the same as Spot

Impossible to tell



This is a rectangle.

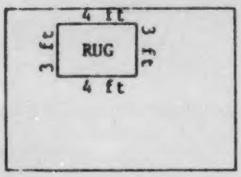
The rectangle is 4 feet long on one side and 6 feet long on another side.

TRUE FALSE

The area of the rectangle is: 10 sq ft 20 sq ft 24 sq ft 100 sq ft

The area of the floor of a room pictured below is 96 sq ft. A small rug is on the floor.

The area of the floor not covered by the rug is:



79 sq ft

82 sq ft

84 sq ft

89 sq ft

impossible to tell

Measurements

2 cups = 1 pint

2 pints = 1 quart

4 quarts = 1 gallon

2 half gallons = 1 gallon

A gallon is larger than a pint.

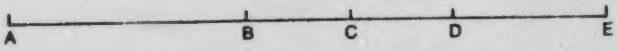
TRUE FALSE

Solve the sentence.

16 quarts = ☐ gallons

Solve the sentence.

2 gallons = ☐ cups



The distance from A to E is 23 cm.

The distance from D to A is 17 cm.

The distance from B to E is 14 cm.

C is half-way between B and D.

What is the distance from A to D? ______________

What is the distance from A to B? ______________

What is the distance from B to C? ______________

The dining room of a ship has 14 tables. One-half of the tables have 6 chairs at each table and the other half of the tables have 4 chairs at each table.

7 tables have 6 chairs at each table. TRUE FALSE

What is the largest number of people that can sit in the dining room at one time? ______________

Another ship has 70 passengers. If all of the passengers and crewmen are sitting in the lifeboats, there are 7 passengers and 2 crewmen in each lifeboat.

How many crewmen are on the ship? ______________

Put a number in each ☐ to complete the number pattern.

1 2 3 ☐ 5 6

4 7 10 ☐ 16 19

1 2 4 7 ☐ 16 22

Rosemarie had 30 pencils. She lost 16 of them.

She has fewer pencils now. TRUE FALSE IMPOSSIBLE TO TELL

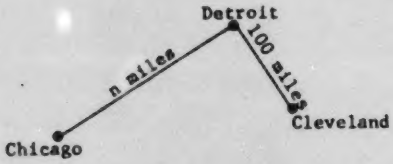
How many pencils does she have now? ______________

Kirk had some pieces of candy. He gave one-half of them to Mary.

Then he gave 3 pieces to Harold and had 6 pieces left.

How many pieces did he start with? ______________

n is the number of miles from Chicago to Detroit.



Circle the true sentence:

It takes n hours to drive from Chicago to Detroit.

n is the number of miles from Detroit to Chicago.

It takes n hours to fly from Chicago to Detroit.

n is the distance in miles from Detroit to Cleveland.

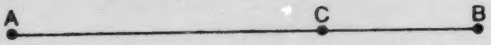
2(n) + 100 represents:

The distance from Chicago to Cleveland.

A distance twice the distance from Chicago to Detroit.

A distance less than the distance between Chicago and Detroit.

A distance more than twice the distance between Chicago and Detroit.



The distance from A to C is twice the distance from C to B.

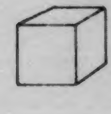
If you drive from A to B and then back to C, you will have gone:

4 times the distance from A to C

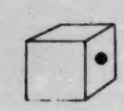
2 times the distance from A to C

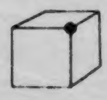
$1\frac{1}{3}$ times the distance from A to C

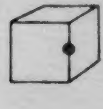
$1\frac{1}{2}$ times the distance from A to C

This is a picture of a cube. 

Circle the picture that has a ● on a face of the cube.

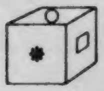


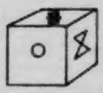


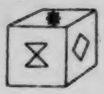


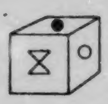
How many faces does a cube have? ______________

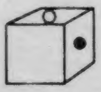
These are four views of the same cube.









Here is another view of the same cube. 

Circle the figure that goes on the □.

✸ ○ □ ⧖ ◊ ●

A ferryboat never crosses the river unless it is full. The ferryboat is full when it holds 12 cars. The ferry is also full when it holds 8 trucks. Cars and trucks are never on the ferryboat at the same time.

Sometimes the ferryboat crosses the river with 10 cars.

TRUE FALSE IMPOSSIBLE TO TELL

In two trips, how many trucks could the ferryboat have carried?

8 12 16 24 none of these

The ferryboat made 4 trips across the river and carried 44 vehicles. (Cars and trucks are vehicles)

Circle the sentence which could be true.

The ferryboat was filled with cars each time.

The ferryboat was filled with trucks each time.

The ferryboat was filled with cars more than one-half the time.

The ferryboat was filled with trucks at least one-half the time.

None of the sentences is true.

Find the sums.

$$\begin{array}{r} 6 \\ +\ 9 \\ \hline \end{array} \qquad \begin{array}{r} 463 \\ +\ 296 \\ \hline \end{array}$$

Find the missing numbers.

$$\begin{array}{r} 3\square 5 \\ +\ 25\square \\ \hline \square 43 \end{array}$$

NAME ______________________

MATH TEACHER ______________________

BOY __________

GIRL __________

ROMBERG-WEARNE
MATHEMATICAL PROBLEM SOLVING TEST

(Time 2)

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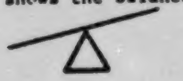
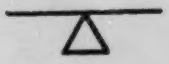
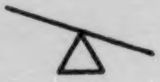
Center Contract No. NE-C-00-3-0065

THESE PROBLEMS ARE ABOUT BALANCE BEAMS.

124. Which picture shows the balance beam in balance?

(A) 

(B) 

(C) 

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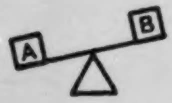
125. 

Which sentence tells about the weights A and B ?

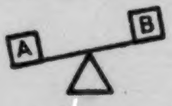
(A) A weighs less than B .

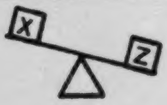
(B) A weighs more than B .

(C) A weighs the same as B .

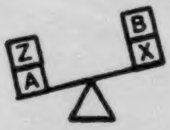
(D) Impossible to tell from the picture.

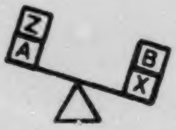
---

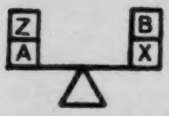
126. 



Weights A and Z are put together on one end of the balance beam and B and X are put together on the other end of the balance beam. Which picture shows how the balance beam might look?

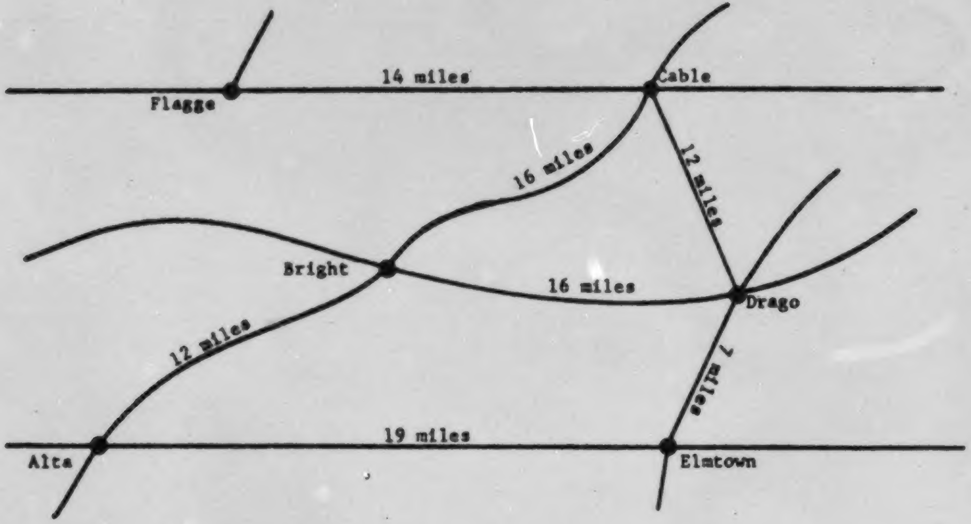
(A) 

(C) 

(B) 

(D) Impossible to tell from the picture.

THESE PROBLEMS ARE ABOUT DISTANCES BETWEEN CITIES ON A MAP.


14 miles
Flagge
Cable
16 miles
12 miles
Bright
16 miles
Drago
12 miles
7 miles
19 miles
Alta
Elmtown

127. The distance from Alta to Bright is:

(A) 7 miles

(B) 12 miles

(C) 16 miles

(D) 19 miles

---

128. The shortest distance from Alta to Drago is:

(A) through Bright

(B) through Cable

(C) through Elmtown

(D) through Flagge

---

129. The sign

BRIGHT	16
ELMTOWN	19

should be placed:

(A) in Drago

(B) in Alta

(C) in Flagge

(D) in Cable

(E) None of these

THESE PROBLEMS ARE ABOUT FISHING.

Jack and Bob went fishing. They both caught two kinds of fish, trout and pike. Bob caught 10 trout. Together they caught 18 trout and 10 pike. Jack caught 15 fish.

130. How many trout did Bob catch?

(A) 10

(B) 15

(C) 18

(D) 28

(E) None of these

131. How many fish did they catch altogether?

(A) 18

(B) 25

(C) 28

(D) 43

(E) None of these

132. How many pike did Bob catch?

(A) 0

(B) 3

(C) 5

(D) 10

(E) None of these

THESE PROBLEMS ARE ABOUT DIFFERENT COLORED HOUSES.

There are 45 houses on Century Avenue. The houses are white, blue, yellow, green, or gray. 18 of the houses are white. There are half as many blue houses as white houses. 15 of the houses are yellow. Only 1 house is gray.

133. There are more blue houses than white houses.

(A) True

(B) False

(C) Impossible to tell

---

134. There are more blue houses than yellow houses.

(A) True

(B) False

(C) Impossible to tell

---

135. How many of the houses are green?

(A) 0

(B) 1

(C) 2

(D) 5

(E) None of these

THESE PROBLEMS ARE ABOUT RELATIONSHIPS BETWEEN THINGS.

136. Which sentence tells about $A < B$?

(A) A is less than B.

(B) A is greater than B.

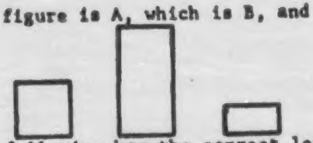
(C) A is equal to B.

---

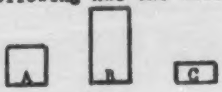
137. The sentences tell about the figures.

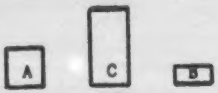
$A < B$
$B < C$

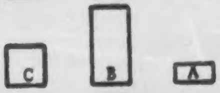
Decide which figure is A, which is B, and which is C.

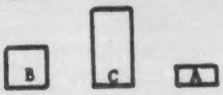


Which of the following has the correct letter written on each figure?

(A) 

(B) 

(C) 

(D) 

(E) None of these

---

138. The following three sentences tell about the numbers A, B, C, and D.

$C + 3 = B$ $D < A$ $B = D - 4$

Which of the following has the numbers A, B, C, D written in order from the smallest to the largest?

(A) A, B, C, D

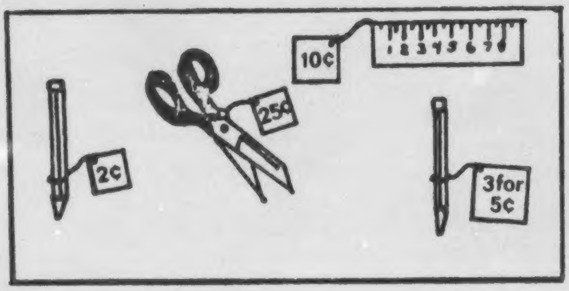
(B) C, B, D, A

(C) B, C, A, D

(D) B, A, D, C

(E) None of these

THESE PROBLEMS ARE ABOUT BUYING PENCILS.



139. Both pencils cost the same.

(A) True

(B) False

(C) Impossible to tell

---

140. How much would 8 of the 2¢ pencils cost?

(A) 8¢

(B) 14¢

(C) 16¢

(D) 26¢

(E) None of these

---

141. What is the greatest number of pencils you could buy for 27¢?

(A) 9

(B) 13

(C) 16

(D) 18

(E) None of these

THESE PROBLEMS ARE ABOUT WEIGHT LOSS.

Jack lost some weight. Susan lost half as much weight as Jack lost. Carol lost half as much weight as Susan lost. Carol lost 10 pounds.

142. Jack lost more weight than Susan.

(A) True

(B) False

(C) Impossible to tell

---

143. Which number tells how many pounds Susan lost?

(A) 5

(B) 10

(C) 20

(D) 40

(E) None of these

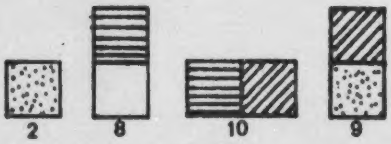
---

144. If Jack weighs 130 pounds now, how many pounds did he weigh before he lost weight?

(A) 140
(B) 150
(C) 160
(D) 170
(E) None of these

THESE PROBLEMS ARE ABOUT BLOCKS COVERING CHIPS.

Each of the four blocks ▤, ▨, □, ░ in the picture below is covering a number of chips. The numbers below the pictures tell how many chips are covered by these blocks.



145. How many chips are covered ░?

(A) 2

(B) 4

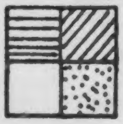
(C) 9

(D) 11

(E) None of these

---

146. How many chips are covered



?

(A) 12

(B) 15

(C) 17

(D) 29

(E) None of these

---

147. How many chips are covered by □?

(A) 0

(B) 4

(C) 5

(D) 8

(E) None of these

THESE PROBLEMS ARE ABOUT CRAYONS.

Judy has twice as many crayons as Mike. Each has more crayons than Karen. Mike has 15 crayons.

148. Karen has the most crayons.

(A) True

(B) False

(C) Impossible to tell

149. How many crayons does Judy have?

(A) 20

(B) 25

(C) 30

(D) 45

(E) None of these

150. Which number tells how many crayons the three could have altogether?

(You don't know exactly how many they have altogether.)

(A) 42

(B) 58

(C) 63

(D) 72

(E) None of these

THESE PROBLEMS ARE ABOUT A PARKING LOT.

A parking lot has room for 8 rows of cars with 9 cars parked in each of those rows.

151. When the parking lot is full, the parking lot has the same number of cars in each of the 8 rows.

(A) True

(B) False

(C) Impossible to tell

---

152. How many cars can be parked in the parking lot?

(A) 8

(B) 9

(C) 64

(D) 72

(E) None of these

---

153. In another parking lot, trucks are parked. Each truck takes the space of 3 cars. There are 12 trucks in the parking lot and it is completely full. If there were 4 rows in the parking lot, how many cars could be parked in each row?

(A) 9

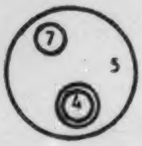
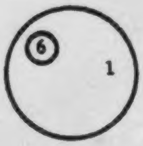
(B) 12

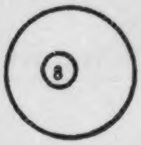
(C) 36

(D) 48

(E) None of these

THESE PROBLEMS ARE ABOUT HOW PEOPLE WRITE NUMBERS IN CIRCLELAND.

In Circleland, people write  when they mean 475 and they write  when they mean 61.

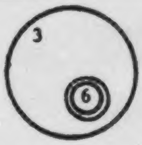
154. In Circleland, people write  when they mean 8.

(A) True

(B) False

(C) Impossible

---

155. What do they mean when they write  ?

(A) 36

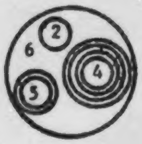
(B) 63

(C) 630

(D) 603

(E) 306

---

156. What do they mean when they write  ?

(A) 4,526

(B) 40,526

(C) 4,562

(D) 45,620

(E) 45,260

THESE PROBLEMS ARE ABOUT HOW MUCH THINGS WEIGH ON THE MOON, MARS, AND EARTH.

Everything weighs 6 times as much on Earth as it does on the Moon.

Everything weighs 2 times as much on Earth as it does on Mars.

157. A box weighs more on the Moon than it does on Earth.

(A) True

(B) False

(C) Impossible to tell

---

158. A box weighs 24 pounds on the Moon. How much does it weigh on Earth?

(A) 4 pounds

(B) 6 pounds

(C) 24 pounds

(D) 144 pounds

(E) None of these

---

159. A dog called Rover weighs 4 pounds on the Moon. Another dog called Spot weighs 12 pounds on Mars.

If both dogs were in the same place, then

(A) Rover would weigh more than Spot.

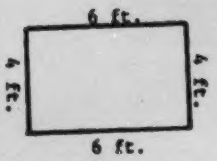
(B) Rover would weigh less than Spot.

(C) Rover would weigh the same as Spot.

(D) Impossible to tell

THESE PROBLEMS ARE ABOUT AREA.

This is a rectangle.



160. The rectangle is 4 feet long on one side and 6 feet long on another side.

(A) True

(B) False

(C) Impossible to tell

---

161. The area of the rectangle is:

(A) 10 sq. ft.

(B) 20 sq. ft.

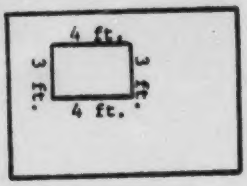
(C) 24 sq. ft.

(D) 100 sq. ft.

(E) None of these

---

162. The area of the floor of a room pictured below is 96 sq. ft. A small rug is on the floor.



The area of the floor not covered by the rug is:

(A) 79 sq. ft.

(B) 82 sq. ft.

(C) 84 sq. ft.

(D) 89 sq. ft.

(E) None of these

THESE PROBLEMS ARE ABOUT LIQUID MEASURE. USE THE TABLE TO HELP YOU ANSWER THE QUESTIONS.

Measurements

2 cups = 1 pint

2 pints = 1 quart

4 quarts = 1 gallon

2 half gallons = 1 gallon

163. A gallon is larger than a pint.

(A) True

(B) False

(C) Impossible to tell

---

164. 16 quarts = ☐ gallons. Which number will solve the sentence?

(A) 1

(B) 2

(C) 3

(D) 4

(E) None of these

---

165. 2 gallons = ☐ cups. Which number will solve the sentence?

(A) 4

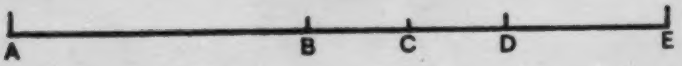
(B) 8

(C) 16

(D) 32

(E) None of these

THESE PROBLEMS ARE ABOUT MEASURING DISTANCES.



The distance from A to E is 23 cm.

The distance from D to A is 17 cm.

The distance from B to E is 14 cm.

C is half-way between B and D.

166. What is the distance from A to D?

(A) 4 cm.

(B) 14 cm.

(C) 17 cm.

(D) 23 cm.

(E) 40 cm.

---

167. What is the distance from A to B?

(A) 2 cm.

(B) 9 cm.

(C) 10 cm.

(D) 12 cm.

(E) None of these

---

168. What is the distance from B to C?

(A) 4 cm.

(B) 5 cm.

(C) 6 cm.

(D) 10 cm.

(E) None of these

THESE PROBLEMS ARE ABOUT PASSENGERS ON A SHIP.

The dining room of a ship has 14 tables. One-half of the tables have 6 chairs at each table and the other half of the tables have 4 chairs at each table.

169. 7 tables have 6 chairs at each table.

(A) True

(B) False

(C) Impossible to tell

---

170. What is the largest number of people that can sit in the dining room at one time?

(A) 14

(B) 24

(C) 70

(D) 140

(E) None of these

---

171. Another ship has 70 passengers. If all of the passengers and crewmen are sitting in the lifeboats, there are 7 passengers and 2 crewmen in each lifeboat. How many crewmen are on the ship?

(A) 2

(B) 14

(C) 20

(D) 70

(E) None of these

THESE PROBLEMS ARE ABOUT NUMBER PATTERNS.

Which number belongs in the ☐ to complete the number pattern.

172. 1 2 3 ☐ 5 6

(A) 3

(B) 4

(C) 5

(D) 8

---

173. 4 7 10 ☐ 16 19

(A) 9

(B) 10

(C) 13

(D) 15

(E) None of these

---

174. 1 2 4 7 ☐ 16 22

(A) 9

(B) 10

(C) 11

(D) 13

(E) None of these

THESE PROBLEMS ARE ABOUT PENCILS AND CANDY.

Rosemarie had 30 pencils. She lost 16 of them.

175. She has fewer pencils now.

(A) True

(B) False

(C) Impossible to tell

---

176. How many pencils does she have now?

(A) 14

(B) 16

(C) 24

(D) 26

(E) None of these

---

177. Kirk had some pieces of candy. He gave one-half of them to Mary. Then he gave 3 pieces to Harold and had 6 pieces left. How many pieces did he start with?

(A) 9

(B) 10

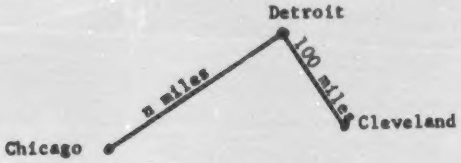
(C) 15

(D) 18

(E) None of these

THESE PROBLEMS ARE ABOUT MEASURING DISTANCES BETWEEN CITIES.

n is the number of miles from Chicago to Detroit.



178. Which is the true sentence?

(A) It takes n hours to drive from Chicago to Detroit.

(B) n is the number of miles from Detroit to Chicago.

(C) It takes n hours to fly from Chicago to Detroit.

(D) n is the distance in miles from Detroit to Cleveland.

---

179. $2(n) + 100$ represents:

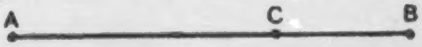
(A) The distance from Chicago to Cleveland.

(B) A distance twice the distance from Chicago to Detroit.

(C) A distance less than the distance between Chicago and Detroit.

(D) A distance more than twice the distance between Chicago and Detroit.

(E) None of these



180. The distance from A to C is twice the distance from C to B. If you drive from A to B and then back to C, you will have gone:

(A) 4 times the distance from A to C.

(B) 2 times the distance from A to C.

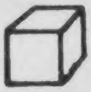
(C) $1\frac{1}{3}$ times the distance from A to C.

(D) $1\frac{1}{2}$ times the distance from A to C.

(E) None of these

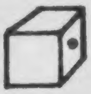
THESE PROBLEMS ARE ABOUT A CUBE.

This is a picture of a cube.

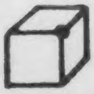


181. Which picture has a ● on a face of the cube?

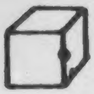
(A)



(B)



(C)



---

182. How many faces does a cube have altogether?

(A) 3

(B) 4

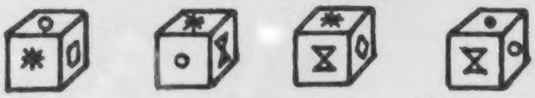
(C) 5

(D) 6

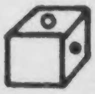
(E) None of these

---

183. These are four views of the same cube.



Here is another view of the same cube.



Which figure goes on the □.

(A) ✳

(B) □

(C) ⧗

(D) ◊

(E) ●

THESE PROBLEMS ARE ABOUT A FERRYBOAT CROSSING A RIVER.

A ferryboat never crosses the river unless it is full. The ferryboat is full when it holds 12 cars. The ferry is also full when it holds 8 trucks. Cars and trucks are never on the ferryboat at the same time.

184. Sometimes the ferryboat crosses the river with 10 cars.

(A) True

(B) False

(C) Impossible to tell

---

185. In two trips, how many trucks could the ferryboat have carried?

(A) 8

(B) 12

(C) 16

(D) 24

(E) None of these

---

186. The ferryboat made 4 trips across the river and carried 44 vehicles. (Cars and trucks are vehicles) Which of the following sentences could be true?

(A) The ferryboat was filled with cars each time.

(B) The ferryboat was filled with trucks each time.

(C) The ferryboat was filled with cars more than one-half the time.

(D) The ferryboat was filled with trucks at least one-half the time.

(E) None of these

THESE PROBLEMS ARE ABOUT FINDING SUMS OF NUMBERS.

187. What is the answer to $\begin{array}{r} 6 \\ +\ 9 \\ \hline \end{array}$?

(A) 14

(B) 15

(C) 16

(D) 17

---

188. What is the answer to $\begin{array}{r} 463 \\ +\ 296 \\ \hline \end{array}$?

(A) 659

(B) 669

(C) 759

(D) 769

(E) None of these

---

189. Which number belongs in the □ ?

$$\begin{array}{r} 3\square 5 \\ +\ 25\bigcirc \\ \hline \triangle 43 \end{array}$$

(A) 0

(B) 1

(C) 8

(D) 9

(E) None of these

APPENDIX C

PILOT TEST MATERIALS FOR ATTITUDE SCALES

POTENTIAL ITEMS FOR INCLUSION IN A SCALE TO MEASURE STUDENTS'ATTITUDES TOWARD PROBLEM SOLVING

The next few pages contain a list of statements which purport to measure fourth grade students' attitudes toward mathematical problem solving. Included are statements reflecting children's beliefs about the nature of some kinds of mathematics problems, the nature of the problem solving process, the desirability of persevering when confronted with a difficult problem, and the value of generating many ideas. Some statements refer to children's ability to succeed in problem solving situations while others deal with sources of children's anxiety in not knowing how to go about solving problems or the fear of being incapable of effective thought.

Many more statements are included in this list than will be used on the final student problem solving attitude scale. Children will be asked to respond to each item by checking one of five responses:

___ Really agree
___ Agree
___ Can't decide
___ Disagree
___ Really disagree

Your candid reactions to the items are solicited and appreciated.

Questions for the reviewer:

(1) In your opinion, is the statement one which would help to reflect a student's attitude toward problem solving?

(2) If yourresponse to (1) is affirmative, does the statement seem to reflect a relatively favorable or relatively unfavorable attitude toward problem solving? Please so indicate before the item.

(3) If your response to (1) is negative, place an X on the number of the item.

PLEASE FEEL FREE TO COMMENT ABOUT, OR MAKE CHANGES IN, ANY ITEM.

The nature of the problem solving process:

1. I don't care how long it takes me to work a problem, just as long as I'm careful.
2. After I have solved a problem, I like to go back and check to see if my answer makes sense.
3. If I don't see how to solve a problem right away, I try different things to see if something might work.
4. I don't worry about making a mistake in solving a problem, just as long as I finish quickly.
5. Before I solve some problems, I like to stop and think about them.
6. After I read a problem and before I solve, I think about what I know and what I don't know in the problem.
7. In math there is always a rule to go by to solve a problem.
8. After I solve a problem, I think it's silly to go back and check to see if my answer makes sense.
9. I like to tell my friends about things I have done in math.
10. I don't like to solve sentences like $21(\square) = 88$.
11. I would rather be in a spelling contest than in a problem solving contest.
12. You have to be careful when you solve a math problem, because some problems don't have answers.
13. I try to read a problem very carefully before I solve it.
14. To solve a problem, you have to put the things you know together with the things you don't know.
15. I like to solve sentences like $11(\square) + (\square) = 56$.
16. Before I solve a problem I like to write down some of the things I know about the problem.
17. It's a good idea to really think about a math problem, because some problems have many answers.

18. I like to draw pictures to help me solve some problems.

19. I like to solve puzzles.

20. I don't like games that make you think.

21. It is fun to think about math problems outside of school.

22. I like to try new games.

23. I like to play games that really make you think.

24. Puzzles are dumb.

25. I think it's silly to draw pictures to help solve a problem.

26. Puzzles are fun.

Success in solving problems:

27. If I had a hundred years, I don't think I could solve some problems.

28. I don't mind taking a chance on making a mistake when I try to solve a problem.

29. Trying to solve a new type of math problem is too hard for me.

30. There are too many chances to make a mistake in solving math problems.

31. If I had plenty of time, I could be better at solving problems.

32. It is hard for me to really think about what I'm doing in math.

33. I can solve puzzles as well as most of my friends can.

34. There are so many rules to learn in math that I just can't solve problems very well.

35. I can do math problems about as well as most other boys or girls in my class.

The enjoyment of solving mathematics problems:

36. Discovering how to solve a new math problem makes me feel happy.

37. Doing math problems is fun.

38. I like to do math problems that are quick and easy.

39. I don't like to work on math problems outside of school.

40. I never get tired of working with numbers.

41. I wish we could spend more time in school doing math problems.

42. Math is one of my favorite subjects in school.

43. I like to figure and reason out math problems.

44. Sometimes I do extra work in math just for fun.

45. Doing math problems is boring.

46. Solving math problems is dull.

47. I don't enjoy solving any kind of math problem.

48. I like most other school subjects better than math.

49. Trying to discover how to solve a new math problem gives me a pain.

50. I would rather do almost anything else than try to solve a math problem.

Anxiety when solving problems:

51. There is so much hard work in trying to solve a math problem that sometimes I just want to throw my paper away.

52. Sometimes I get very upset if I can't solve a problem.

53. There are just too many steps needed to get the answers to math problems.

54. My mind goes blank, and I can't think straight when working math problems.

55. I don't understand how some students think that solving math problems is fun.

56. No matter how hard I try, I can't understand how to solve math problems.

57. It makes me nervous just to think about having to do a math problem.

58. Math problems make me feel like I'm lost in a jungle of numbers and can't find my way out.

59. I am afraid of doing problems.

60. I get very mad when I can't solve a math problem.

Reactions to mathematics problems:

61. Math problems are dumb.

62. I like the problem

$$359 + 574 - 684 + 999 + 466 - 72 + 839 = \boxed{}$$

better than the problem

Jane is half as tall as Dick. Joe is half as tall as Jane. Mark is half as tall as Joe. Dick is 60 inches tall. How tall is Joe?

63. The feeling that I have toward math problems is a good feeling.

64. I don't like any kind of math problem.

65. Math problems are fun.

66. Most problems in math are very interesting.

67. I would like math problems better if they weren't so hard.

68. Math problems are easy to understand.

69. Math problems are more like games than hard work.

70. I like tricky math problems.

71. The feeling that I have toward math problems is a bad feeling.

72. Math problems are never interesting.

Perseverance in solving problems:

73. When we don't do all our math problems in class, I like to think about them later, even if we don't have to.

74. I don't like to do problems unless I see how to work them right away.

75. There are too many steps needed to get the answer to a math problem.

76. I would rather have someone tell me how to solve a hard problem than to have to work it out for myself.

77. I can't make myself think about a problem long enough to solve it.

78. I would rather solve a problem myself than have someone show me how to solve it.

79. When I have a problem that I can't solve right away, I stick with it until I have it solved.

80. Most math problems take too long to solve.

81. When I have a problem that I can't solve right away, I just give up.

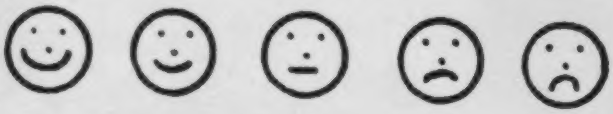
82. When we don't do all our math problems in class, I don't like to even think about them later.

STUDENT SCALE

(Pilot)

DIRECTIONS: In this part of the booklet are some statements that are not finished. We want you to finish each statement by telling us how you feel about the statement. Here is an example to show you what to do.

EXAMPLE: The way I feel about doing subtraction problems is



Put an X on the face that tells how you feel about the statement.

Remember, there are no right or wrong answers. You may not feel the same way that other students do, but that is all right. Just mark exactly how you feel.

When you come to the word STOP, wait for directions before going on.

YOU MAY TURN THE PAGE AND BEGIN.

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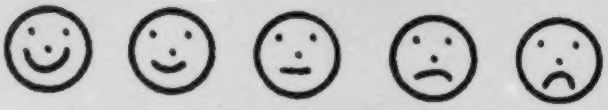
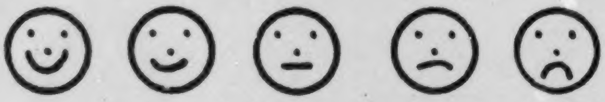
Center Contract No. NE-C-00-3-0065

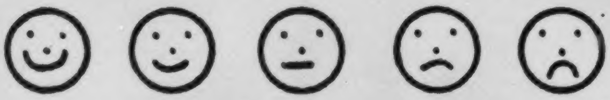
1. Talking about things we do in math makes me feel



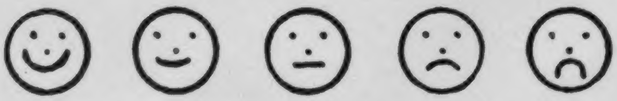
2. The way I feel about hard math problems is



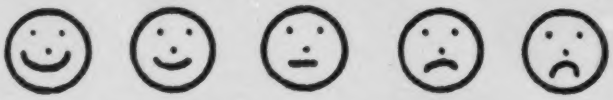
3. The way I feel about solving puzzles is



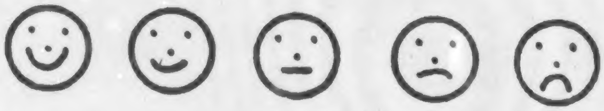
4. Finding out how to solve a new kind of math problem makes me feel



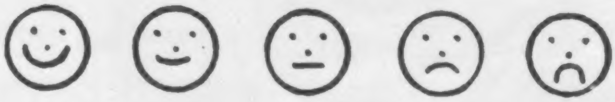
5. The way I feel about long math problems is



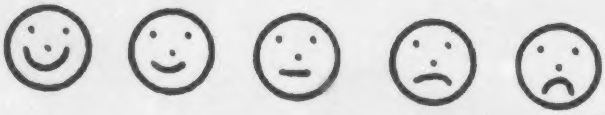
6. Thinking about math problems outside of school makes me feel



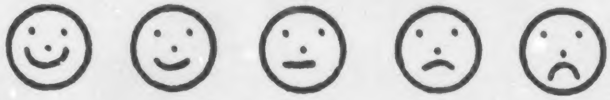
7. The way I feel about drawing pictures to help me solve some problems is



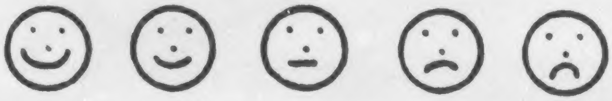
8. The way I feel about math class is



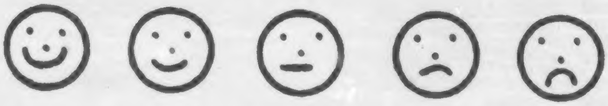
9. Trying new kinds of games makes me feel



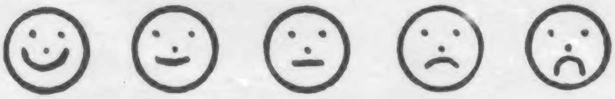
10. The way I feel about doing math problems is



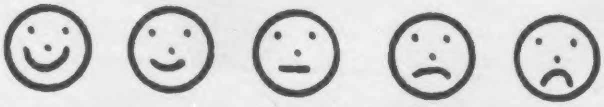
11. The way I feel about playing games that really make you think is



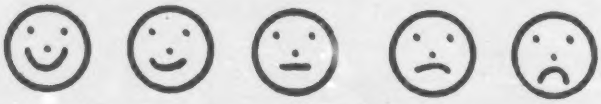
12. Trying to work a new kind of math problem makes me feel



13. The way I feel about tricky math problems is



14. If we spent more time in school doing math problems, I would be



STOP. WAIT FOR MORE DIRECTIONS BEFORE GOING ON.

In this next part are some statements made by boys and girls like you. We want you to read the statements and then tell us how you feel about them. Here is an example to show you what to do.

EXAMPLE: I like to work addition problems.

_____REALLY AGREE
_____AGREE
_____CAN'T DECIDE
_____DISAGREE
_____REALLY DISAGREE

Put an X in the blank which tells how you feel about the statement.

If you feel the same way about the statement, put an X by AGREE.
If you _really_ feel the same way, put an X by REALLY AGREE.
If you don't feel the same way, put an X by DISAGREE.
If you _really_ don't feel the same way, put an X by REALLY DISAGREE.
If you are not sure how you feel, put an X by CAN'T DECIDE.

There are no right or wrong answers in this part either. Just mark exactly how _you_ feel.

When you finish, put your pencil down and wait quietly for the rest of the class to finish.

15. I have a hard time thinking when I try to work a math problem.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

16. Math problems are more like games than hard work.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

17. After I get an answer to a problem, I think it's silly to go back and check to see if my answer makes sense.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

18. I like the problem

$$359 + 574 - 684 + 999 + 466 - 72 + 839 = \boxed{}$$

better than I like the problem

Emily is half as tall as Darrell. Andy is half as tall as Emily. Chad is half as tall as Andy. Darrell is 60 inches tall. How tall is Andy?

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

19. I would rather work a problem myself than have someone show me how to work it.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

20. There are just too many steps needed to get the answers to most math problems.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

21. It makes me nervous just to think about having to do a math problem.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

22. I can do math problems about as well as most other students in my class.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

23. Trying to solve a new kind of math problem is hard for me.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

24. I don't mind taking a chance on making a mistake when I solve a problem.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

25. Before I work some problems, I like to stop and think about them.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

26. I can't make myself think about a problem long enough to solve it.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

27. I try to read a problem carefully before I solve it.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

28. I would rather do almost anything else than try to solve a math problem.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

29. When I have a problem that I can't solve right away, I stick with it until I have it solved.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

30. I don't understand why some students think that solving math problems is fun.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

31. I don't like to do problems unless I see how to work them right away.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

32. I am afraid of doing math problems.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

33. No matter how hard I try, I have trouble understanding math problems.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

34. If I don't see how to solve a problem right away, I like to try different things to see if something might work.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

35. Math problems are dumb.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

36. After I read a problem, I like to think about what I know and what I don't know in the problem.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

37. Before I work a problem it sometimes helps to write down some of the things I know about the problem.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

38. Math problems make me feel like I'm lost in a jungle of numbers and can't find my way out.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

39. There are so many rules to learn in math that I just can't solve problems very well.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

40. I don't worry about making a mistake when I work a problem, just as long as I finish quickly.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

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                                          UNIVERSITY OF WISCONSIN
                                          DEPARTMENT OF SOCIOLOGY
                                           ITEM ANALYSIS PACKAGE
                               D WHITAKER -- PILOT STUDY OF STUDENT'S INTRUMENT
                           ITEM ANALYSIS FOR SCORE  1: FIRST HALF

A CONSTANT OF     0 HAS BEEN ADDED TO THIS SCORE

CRONBACHS ALPHA =  .8351

STANDARD ERROR OF MEASUREMENT =     3.316

ITEM TO TOTAL CORRELATIONS

             1         2         3         4         5         6         7         8         9        10
          .50357    .67904    .38202    .67428    .63739    .56393    .13236    .76244    .21694    .80307

            11        12        13        14
          .46392    .80581    .63233    .66126


CURETON CORRECTED ITEM TO TOTAL CORRELATIONS

             1         2         3         4         5         6         7         8         9        10

          .41304    .60052    .30349    .59640    .55698    .45560   -.02524    .71690    .15200    .76257

            11        12        13        14

          .38068    .77537    .55349    .54804
```

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                        UNIVERSITY OF WISCONSIN
                        DEPARTMENT OF SOCIOLOGY
                         ITEM ANALYSIS PACKAGE
              D WHITAKER -- PILOT STUDY OF STUDENT'S INTRUMENT
           ITEM ANALYSIS FOR SCORE  2: SECOND HALF

A CONSTANT OF     0 HAS BEEN ADDED TO THIS SCORE

CRONBACHS ALPHA =  .8585

STANDARD ERROR OF MEASUREMENT =     5.363

ITEM TO TOTAL CORRELATIONS

           15        16        17        18        19        20        21        22        23        24
        .63376    .48560    .36215   -.02806    .21203    .54624    .70293    .29652    .62876    .28438

           25        26        27        28        29        30        31        32        33        34
        .50154    .51343    .36854    .75501    .32036    .69944    .66290    .43938    .50730    .01915

           35        36        37        38        39        40
        .75653    .39636    .27119    .63785    .68641    .47653


CURETON CORRECTED ITEM TO TOTAL CORRELATIONS

           15        16        17        18        19        20        21        22        23        24

        .58266    .41949    .27963   -.11937    .14111    .49075    .65795    .20922    .57903    .20206

           25        26        27        28        29        30        31        32        33        34

        .45129    .45655    .32012    .72275    .24015    .64971    .61237    .37659    .45323   -.05059

           35        36        37        38        39        40

        .72229    .32817    .20069    .58331    .64301    .41005
```

```
                              UNIVERSITY OF WISCONSIN
                              DEPARTMENT OF SOCIOLOGY
                               ITEM ANALYSIS PACKAGE
                   D WHITAKER -- PILOT STUDY OF STUDENT'S INTRUMENT
                ITEM ANALYSIS FOR SCORE  3: ENTIRE INSTRUMENT

A CONSTANT OF      0 HAS BEEN ADDED TO THIS SCORE

CRONBACHS ALPHA =  .9316

STANDARD ERROR OF MEASUREMENT =     6.407

ITEM TO TOTAL CORRELATIONS

          1         2         3         4         5         6         7         8         9        10
     .43172    .54756    .35009    .49635    .58542    .38203    .00935    .67797    .18876    .69502

         11        12        13        14        15        16        17        18        19        20
     .29267    .67913    .65258    .66586    .59307    .56413    .25537   -.10326    .19225    .56039

         21        22        23        24        25        26        27        28        29        30
     .65893    .25343    .61948    .23395    .55282    .44285    .42794    .72222    .34659    .71594

         31        32        33        34        35        36        37        38        39        40
     .56523    .39893    .48163   -.02651    .79836    .39630    .31004    .63172    .60732    .38790


CURETON CORRECTED ITEM TO TOTAL CORRELATIONS

          1         2         3         4         5         6         7         8         9        10

     .39405    .50611    .31869    .45544    .55151    .33140   -.05353    .65301    .16283    .66809

         11        12        13        14        15        16        17        18        19        20

     .25551    .65645    .62431    .62587    .55416    .52375    .19466   -.16609    .14271    .52287

         21        22        23        24        25        26        27        28        29        30

     .62284    .19184    .58408    .17568    .52066    .40117    .39624    .69557    .29225    .68299

         31        32        33        34        35        36        37        38        39        40

     .52150    .35371    .44301   -.07503    .77837    .34779    .26234    .59328    .56994    .33748
```

POTENTIAL ITEMS FOR INCLUSION IN A SCALE TO MEASURE TEACHERS' ATTITUDES TOWARD PROBLEM SOLVING

The next few pages contain a list of statements which purport to measure elementary teachers' attitudes toward mathematical problem solving. For comparative purposes, and insofar as possible, the items "parallel" those included in the student list.

Many more statements are included in this list than will be used on the final teacher problem solving attitude scale. Teachers will be asked to respond to each item by checking one of five responses:

__Strongly agree
__Agree
__Undecided
__Disagree
__Strongly disagree

Your candid reactions to the items are solicited and appreciated.

Questions for the reviewer:

(1) In your opinion, is the statement one which would help to reflect a teacher's attitude toward problem solving?

(2) If your response to (1) is affirmative, does the statement seem to reflect a relatively favorable or relatively unfavorable attitude toward problem solving? Please so indicate before the item.

(3) If your response to (1) is negative, place an X on the number of the item.

PLEASE FEEL FREE TO COMMENT ABOUT, OR MAKE CHANGES IN, ANY ITEM.

The nature of the problem solving process:

1. Accuracy in solving a problem is more important than speed.
2. Few mathematics problems require one to stop and think before solving.
3. After solving a problem, it is of little value to go back and check to see if the answer makes sense.
4. A person should be careful in solving mathematics problems because some problems do not have answers.
5. I do not like to solve puzzles of any type.
6. It is a waste of time to draw a figure to help solve a mathematics problem.
7. Accuracy is of little importance in solving a problem, as long as an answer can be obtained quickly.
8. After reading a problem, and before solving, it is a good idea to think about the known and unknown factors in the problem.
9. I enjoy trying new games.
10. I prefer relaxing games to those which make one think.
11. I enjoy playing games that really make a person think.
12. When a question about a mathematics problem is left unanswered, I like to think about it later.
13. I have always enjoyed solving number sentences.
14. Drawing figures to help solve problems is helpful.
15. If a person does not see how to solve a problem right away, it is a good idea to try different approaches to see if something might work.
16. After solving a problem, it is a good idea to go back and check to see if the answer makes sense.
17. Mathematics is little more than a series of rules to be learned before solving problems.
18. I enjoy solving all types of puzzles.
19. It is a good idea to think carefully about a mathematics problem because some problems have many answers.

Success in solving problems:

20. The number of rules one must learn in mathematics makes solving problems difficult.

21. There are too many chances to make a mistake when solving mathematics problems.

22. Even if I had unlimited time, I do not think I could solve some mathematics problems.

23. I have always been able to solve puzzles as well as most of the people I know.

24. Trying to solve a new type of mathematics problem is difficult.

25. I often have difficulty in knowing how to go about solving a problem.

26. I do not mind solving problems if I see how to work them right away.

27. If I had plenty of time, I believe I could be successful at solving most mathematics problems.

28. A person should not mind taking a chance on making a mistake when solving a problem.

29. I believe I am as successful at solving mathematics problems as most other elementary teachers.

Enjoyment of solving problems:

30. Doing mathematics problems has always been fun for me.

31. I enjoy solving all kinds of problems.

32. Discovering the solution to a new mathematics problem is exciting.

33. I always liked most other school subjects better than mathematics.

34. I have always enjoyed doing mathematics problems as long as they are easy and uncomplicated.

35. Mathematics was one of my favorite subjects in school.

36. I have usually found mathematics to be a dull subject.

37. I do not particularly like doing difficult mathematics problems.

38. Solving mathematics problems is boring.

39. I have always enjoyed solving mathematics problems.

40. Mathematics problems are something I enjoy a great deal.

41. I have always thought that mathematics problems are more like games than hard work.

42. I enjoy working on a tricky mathematics problem.

43. I have always considered mathematics problems to be a form of drudgery.

44. The feeling that I have toward mathematics problems is a pleasant feeling.

45. Mathematics problems take too long to solve.

46. Most problems in mathematics are not very practical.

47. I have always found mathematics problems to be dull and boring.

48. I have always felt that mathematics problems are fascinating and fun.

49. Mathematics problems, generally, are very interesting.

50. Most mathematics problems are frustrating.

Anxiety when solving problems:

51. I have trouble understanding why some students think mathematics problems are fun.

52. I often find myself unable to think clearly when working mathematics problems.

53. It often makes me nervous to think about having to solve difficult mathematics problems.

54. Mathematics problems often make me feel as though I am lost in a jungle of numbers and cannot find my way out.

55. Trying to discover the solution to a new problem is a frustrating experience.

56. I tend to get very upset with myself if I do not see how to solve a difficult problem.

57. Some mathematics problems just involve too many steps to bother with solving them.

58. Regardless of how much effort I put forth, I still experience a feeling of confusion when solving mathematics problems.

59. One might say that I have a fear of solving mathematics problems.

Perseverance in solving problems:

60. I would rather have someone tell me how to solve a difficult problem than to have to work it out for myself.

61. If I cannot solve a problem right away, I like to stick with it until I have it solved.

62. I have difficulty making myself think about a problem long enough to solve it.

63. I do not particularly enjoy thinking about mathematics problems outside of school.

64. I have always felt that there are too many steps necessary to solve most mathematics problems.

65. I enjoy thinking about mathematics problems outside of school.

66. I have always found it difficult to concentrate on mathematics problems for a very long period of time.

67. Most mathematics problems, other than the simplest types, take too long to solve.

68. I would rather solve a problem myself than have someone show me how to solve it.

69. If I cannot solve a problem right away, I tend to give up.

70. I can always find time to work on mathematics problems.

The teaching of problem solving:

71. I encourage my students to use trial-and-error when solving many math problems.

72. I like to stress with my students that there are often many different ways to solve the same problem.

73. A teacher should always do sample problems for students before making an assignment.

74. I think students should be encouraged to use the method that suits them best when solving a problem.

75. I like to spend much of the time in math class showing students how to work problems.

76. Students need drill in problem solving skills just as they need drill in computational skills.

77. A teacher should insist that students find their own methods for solving problems.

78. Memorizing procedures to solve problems is helpful for most students.

79. I like to emphasize with my students that, in mathematics, some problems have many answers, and some problems have no answer.

80. Knowing how to compute is about all that is necessary for solving most math problems.

81. I encourage my students to check their answers to problems to see if the answers actually make sense.

82. Students who do not see how to solve a problem right away should be encouraged to try and think of another problem like that one.

83. A teacher should demonstrate models for solving problems so the students can imitate them.

84. I like to encourage my students to adopt a stop-and-think attitude when solving problems.

85. The development of computational skills should take precedence over the development of problem solving skills in the teaching of elementary mathematics.

TEACHER SCALE

(Pilot)

On the next few pages are some statements related to mathematical problem solving. Read each statement, think about it, and mark the response which best represents your feelings with regard to the statement. Five possible responses are listed for each item.

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Center Contract No. NE-C-00-3-0065

1. I have always found solving mathematics problems to be dull and boring.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

2. I enjoy playing games that involve some intellectual challenge.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

3. The feeling that I have toward mathematics problems is a pleasant feeling.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

4. I do not like to solve puzzles of any type.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

5. One might say that I have a fear of solving mathematics problems.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

6. Regardless of how much effort I put forth, I still experience a feeling of confusion when solving mathematics problems.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

7. After solving a problem, it is of little value to go back and check to see if the answer makes sense.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

8. I enjoy thinking about mathematics problems outside of school.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

9. Trying to solve a new type of mathematics problem is a frustrating experience.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

10. I have always thought that mathematics problems are more like games than hard work.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

11. If I cannot solve a problem right away, I tend to give up.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

12. I believe I am as successful at solving mathematics problems as most other teachers.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

13. Mathematics problems, generally, are very interesting.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

14. Mathematics problems take too long to solve.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

15. The number of rules one must learn in mathematics makes solving problems difficult.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

16. Mathematics problems often make me feel as though I am lost in a jungle of numbers and cannot find my way out.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

17. Doing mathematics problems has always been fun for me.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

18. I have trouble understanding why some students think mathematics problems are fun.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

19. If I had plenty of time, I believe I could be successful at solving most mathematics problems.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

20. If a person does not see how to solve a problem right away, it is a good idea to try different approaches to see if something might work.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

21. I enjoy trying new games.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

22. I enjoy solving puzzles.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

23. Drawing digures to help solve some problems is helpful.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

24. Most mathematics problems are frustrating.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

25. I do not mind solving mathematics problems if I see how to work them right away.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

26. I have difficulty making myself think about a problem long enough to solve it.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

27. I enjoy working on a tricky mathematics problem.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

28. After reading a problem, and before solving, it is a good idea to think about the known and unknown factors in the problem.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

29. I do not particularly enjoy thinking about mathematics problems outside of school.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

30. I would rather solve a problem myself than have someone show me how to solve it.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

31. After solving a problem, it is a good idea to go back and check to see if the answer makes sense.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

32. I enjoy solving all kinds of problems.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

33. Some mathematics problems just involve too many steps to bother with solving them.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

34. I have always considered mathematics problems to be a form of drudgery.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

35. It is a waste of time to draw a figure to help solve a mathematics problem.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

36. Trying to discover the solution to a new type of mathematics problem is an exciting experience.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

37. I often find myself unable to think clearly when trying to solve mathematics problems.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

38. Mathematics problems are something I enjoy a great deal.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

39. If I cannot solve a problem right away, I like to stick with it until I have it solved.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

40. A person should not mind taking a chance on making a mistake when solving a problem.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

41. Most mathematics problems, other than the simplest types, take too long to solve.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

42. When a question about a mathematics problem is left unanswered, I like to think about it later.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

43. I am challenged by mathematics problems I cannot immediately solve.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

44. It is a good idea to think carefully about mathematics problems, because some problems have many answers.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

45. Discovering the solution to a new mathematics problem is exciting.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

46. It makes me nervous to think about having to solve difficult mathematics problems.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

47. I do not particularly like doing difficult mathematics problems.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

48. I have always found it difficult to concentrate on mathematics problems for a very long period of time.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

49. Mathematics is little more than a series of rules to be learned before solving problems.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

50. I would rather have someone tell me how to solve a difficult problem than to have to work it out for myself.

_____Really agree
_____Agree
_____Can't decide
_____Disagree
_____Really disagree

```
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                              DEPARTMENT OF SOCIOLOGY
                               ITEM ANALYSIS PACKAGE
                    WHITAKER -- PILOT TEST OF TEACHER'S INSTRUMENT
                 ITEM ANALYSIS FOR SCORE  1 TEACHER INSTRUMENT

A CONSTANT OF    0 HAS BEEN ADDED TO THIS SCORE

CRONBACH-S ALPHA =  .9627

STANDARD ERROR OF MEASUREMENT =    5.737

ITEM TO TOTAL CORRELATIONS

            1         2         3         4         5         6         7         8         9        10
        .62918    .25171    .71298    .36771    .69302    .52330    .41651    .57381    .78801    .77941

           11        12        13        14        15        16        17        18        19        20
        .67264    .77155    .82487    .37433    .62368    .82332    .45731    .62168    .69206    .56633

           21        22        23        24        25        26        27        28        29        30
        .71550    .58950    .26069    .82339    .37933    .77347    .76504    .15424    .67707    .34147

           31        32        33        34        35        36        37        38        39        40
        .06284    .57883    .52163    .64528    .50247    .85335    .71889    .88211    .65173    .53068

           41        42        43        44        45        46        47        48        49        50
        .71240    .44132    .84220    .17506    .72421    .77761    .68675    .77635    .34372    .57563


CURETON CORRECTED ITEM TO TOTAL CORRELATIONS

            1         2         3         4         5         6         7         8         9        10

        .60232    .22001    .68942    .35356    .66737    .49115    .39351    .54892    .77421    .76527

           11        12        13        14        15        16        17        18        19        20

        .65450    .75625    .81418    .34279    .60479    .81211    .42525    .59699    .67388    .55423

           21        22        23        24        25        26        27        28        29        30

        .70445    .57096    .22798    .81324    .34951    .76291    .75040    .13683    .65756    .31379

           31        32        33        34        35        36        37        38        39        40

        .04595    .55797    .49706    .62752    .48830    .84562    .70141    .87454    .63483    .51704

           41        42        43        44        45        46        47        48        49        50

        .69732    .41327    .83189    .14663    .71173    .76276    .67605    .76231    .31156    .55234
```

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APPENDIX D

MATHEMATICAL PROBLEM SOLVING ATTITUDE SCALES

YOUR FIRST NAME________________________

TEACHER'S NAME_________________________

____Girl

____Boy

STUDENT SCALE

(Time 1)

Experimental Copy

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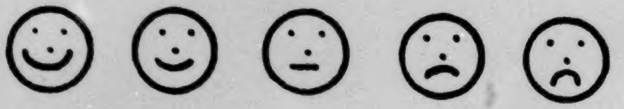
Center Contract No. NE-C-00-3-0065

PART I

DIRECTIONS: In this part of the booklet are some statements that are not finished. We want you to finish each statement by telling us how you feel about the statement. Here is an example to show you what to do.

EXAMPLE: The way I feel about doing subtraction problems is



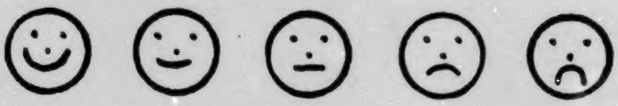
Put an X on the face that tells how you feel about the statement.

Remember, there are no right or wrong answers. You may not feel the same way that other students do, but that is all right. Just mark exactly how _you_ feel.

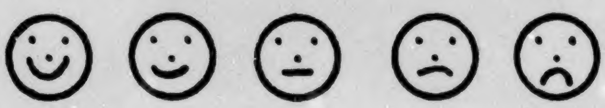
When you come to the word STOP, wait for directions before going on.

YOU MAY TURN THE PAGE AND BEGIN.

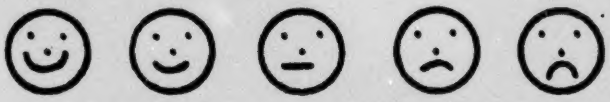
1. The way I feel about math class is



2. The way I feel about long math problems is



3. The way I feel about solving puzzles is



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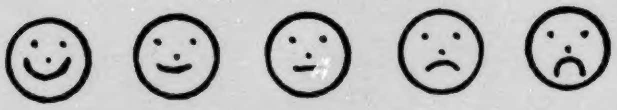
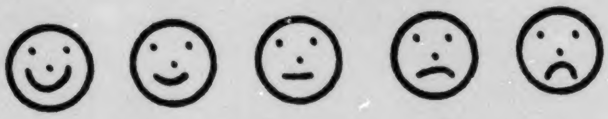
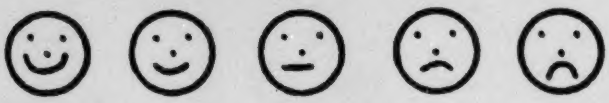


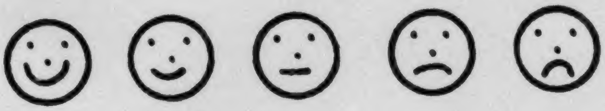
5. If we spent more time in school doing math problems, I would be



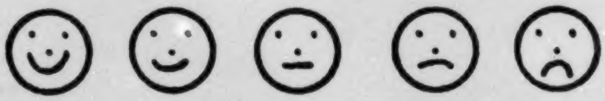
6. Finding out how to solve a new kind of math problem makes me feel



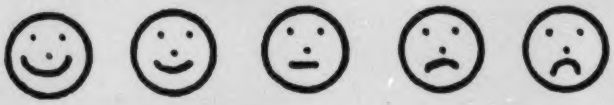
7. Thinking about math problems outside of school makes me feel



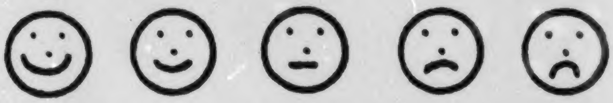
8. The way I feel about tricky math problems is



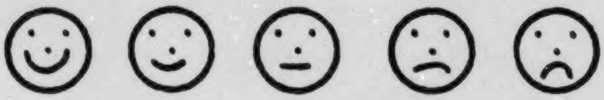
9. Trying to work a new kind of math problem makes me feel



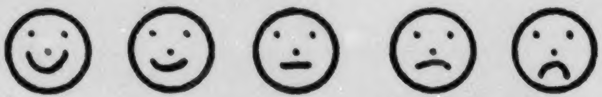
10. Talking about things we do in math makes me feel



11. The way I feel about hard math problems is



12. The way I feel about playing games that really make you think is



STOP. WAIT FOR DIRECTIONS BEFORE GOING ON.

PART II

In this next part are some statements made by boys and girls like you. We want you to read the statements and then tell us how you feel about them. Here is an example to show you what to do.

EXAMPLE: I like to work most addition problems.

_____REALLY AGREE
_____AGREE
_____CAN'T DECIDE
_____DISAGREE
_____REALLY DISAGREE

Put an X in the blank which tells how you feel about the statement.

If you feel the same way about the statement, put an X by AGREE.
If you _really_ feel the same way, put an X by REALLY AGREE.
If you don't feel the same way, put an X by DISAGREE.
If you _really_ don't feel the same way, put an X by REALLY DISAGREE.
If you are not sure how you feel, put an X by CAN'T DECIDE.

There are no right or wrong answers in this part either. Just mark exactly how _you_ feel.

When you finish, put your pencil down and wait quietly for the rest of the class to finish.

13. I don't like to do problems unless I see how to work them right away.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

14. After I read a problem, I like to think about what I know and what I don't know in the problem.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

15. I would rather do almost anything else than try to solve a math problem.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

16. When I have a problem that I can't solve right away, I stick with it until I have it solved.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

17. I would rather work a problem myself than have someone show me how to work it.

_____REALLY AGREE
_____AGREE
_____CAN'T DECIDE
_____DISAGREE
_____REALLY DISAGREE

18. I am afraid of doing math problems.

_____REALLY AGREE
_____AGREE
_____CAN'T DECIDE
_____DISAGREE
_____REALLY DISAGREE

19. Before I work a problem it sometimes helps to write down some of the things I know about the problem.

_____REALLY AGREE
_____AGREE
_____CAN'T DECIDE
_____DISAGREE
_____REALLY DISAGREE

20. Trying to solve a new kind of math problem is hard for me.

_____REALLY AGREE
_____AGREE
_____CAN'T DECIDE
_____DISAGREE
_____REALLY DISAGREE

21. Math problems are more like games than hard work.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

22. No matter how hard I try, I have trouble understanding math problems.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

23. I try to read a problem carefully before I solve it.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

24. Math problems are dumb.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

25. Math problems make me feel like I'm lost in a jungle of numbers and can't find my way out.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

26. There are so many rules to learn in math that I just can't solve problems very well.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

27. It makes me nervous just to think about having to do a math problem.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

28. I don't mind taking a chance on making a mistake when I try to solve a problem.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

29. There are just too many steps needed to get the answers to most math problems.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

30. I can't make myself think about a problem long enough to solve it.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

31. I have a hard time thinking when I try to work a math problem.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

32. After I get an answer to a problem, I think it's silly to go back and check to see if my answer makes sense.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

33. I can do math problems about as well as most other students in my class.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

34. Before I work some problems, I like to stop and think about them.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

35. I don't understand why some students think that solving math problems is fun.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

36. I don't worry about making a mistake when I work a problem, just as long as I finish quickly.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

YOUR FIRST NAME________________________

TEACHER'S NAME________________________

____Girl

____Boy

STUDENT SCALE

(Time 2)

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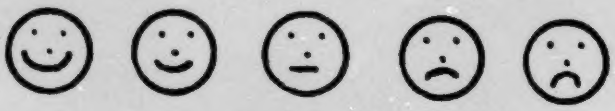
Center Contract No. NE-C-00-3-0065

PART I

DIRECTIONS: In this part of the booklet are some statements that are not finished. We want you to finish each statement by telling us how you feel about the statement. Here is an example to show you what to do.

EXAMPLE: The way I feel about doing subtraction problems is



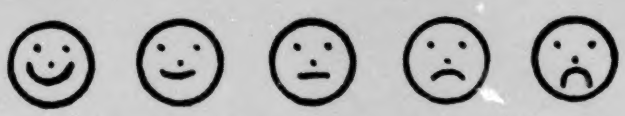
Put an X on the face that tells how you feel about the statement.

Remember, there are no right or wrong answers. You may not feel the same way that other students do, but that is all right. Just mark exactly how you feel.

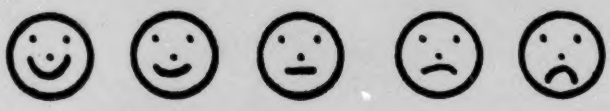
When you come to the word STOP, wait for directions before going on.

YOU MAY TURN THE PAGE AND BEGIN.

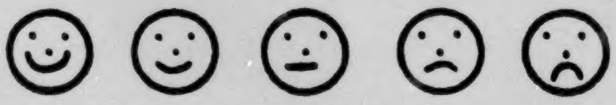
1. If we spent more time in school doing math problems, I would be



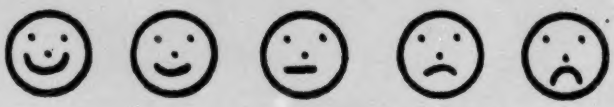
2. The way I feel about solving puzzles is



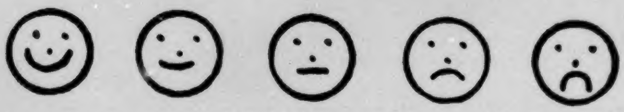
3. Finding out how to solve a new kind of math problem makes me feel



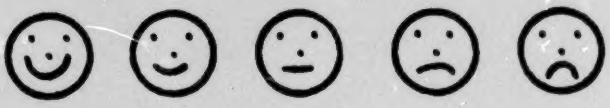
4. The way I feel about hard math problems is



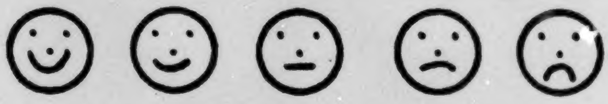
5. Talking about things we do in math makes me feel



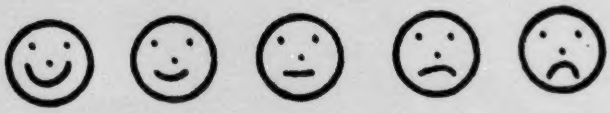
6. The way I feel about long math problems is



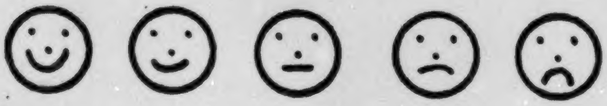
7. Thinking about math problems outside of school makes me feel



8. The way I feel about playing games that really make you think is



9. Trying to work a new kind of math problem makes me feel



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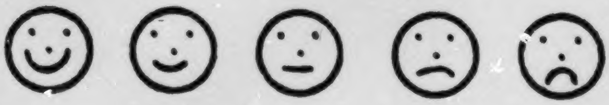
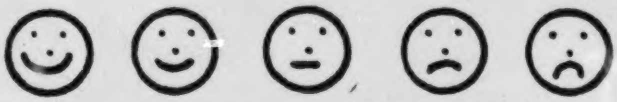
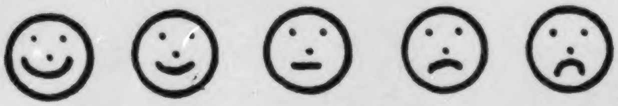


11. The way I feel about doing math problems is



12. The way I feel about math classs is



STOP. WAIT FOR DIRECTIONS BEFORE GOING ON.

PART II

In this next part are some statements made by boys and girls like you. We want you to read the statements and then tell us how you feel about them. Here is an example to show you what to do.

EXAMPLE: I like to work most addition problems.

_____REALLY AGREE
_____AGREE
_____CAN'T DECIDE
_____DISAGREE
_____REALLY DISAGREE

Put an X in the blank which tells how you feel about the statement.

If you feel the same way about the statement, put an X by AGREE.
If you really feel the same way, put an X by REALLY AGREE.
If you don't feel the same way, put an X by DISAGREE.
If you really don't feel the same way, put an X by REALLY DISAGREE.
If you are not sure how you feel, put an X by CAN'T DECIDE.

There are no right or wrong answers in this part either. Just mark exactly how you feel.

When you finish, put your pencil down and wait quietly for the rest of the class to finish.

13. I am afraid of doing math problems.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

14. I don't mind taking a chance on making a mistake when I try to solve a problem.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

15. I would rather work a problem myself than have someone show me how to work it.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

16. After I read a problem, I like to think about what I know and what I don't know in the problem.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

17. I have a hard time thinking when I try to work a math problem.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

18. It makes me nervous just to think about having to do a math problem.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

19. I can't make myself think about a problem long enough to solve it.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

20. I don't like to do problems unless I see how to work them right away.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

21. When I have a problem that I can't solve right away, I stick with it until I have it solved.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

22. Before I work a problem it sometimes helps to write down some of the things I know about the problem.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

23. There are so many rules to learn in math that I just can't solve problems very well.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

24. Math problems are more like games than hard work.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

25. Math problems make me feel like I'm lost in a jungle of numbers and can't find my way out.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

26. Before I work some problems, I like to stop and think about them.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

27. I don't worry about making a mistake when I work a problem, just as long as I finish quickly.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

28. Trying to solve a new kind of math problem is hard for me.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

29. Math problems are dumb.

_____REALLY AGREE
_____AGREE
_____CAN'T DECIDE
_____DISAGREE
_____REALLY DISAGREE

30. I can do math problems about as well as most other students in my class.

_____REALLY AGREE
_____AGREE
_____CAN'T DECIDE
_____DISAGREE
_____REALLY DISAGREE

31. I try to read a problem carefully before I solve it.

_____REALLY AGREE
_____AGREE
_____CAN'T DECIDE
_____DISAGREE
_____REALLY DISAGREE

32. After I get an answer to a problem, I think it's silly to go back and check to see if my answer makes sense.

_____REALLY AGREE
_____AGREE
_____CAN'T DECIDE
_____DISAGREE
_____REALLY DISAGREE

33. I don't understand why some students think that solving math problems is fun.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

34. I would rather do almost anything else than try to solve a math problem.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

35. No matter how hard I try, I have trouble understanding math problems.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

36. There are just too many steps needed to get the answers to most math problems.

_____REALLY AGREE

_____AGREE

_____CAN'T DECIDE

_____DISAGREE

_____REALLY DISAGREE

Time 1

NAME______________________________

SCHOOL____________________________

1. **Have you taught DMP before this school year?**

2. **Have most of your students been in DMP before?**

3. **What DMP topics have you covered thus far this year?**

TEACHER SCALE

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Center Contract No. NE-C-00-3-0065

On this and the following pages are some statements related to mathematical problem solving. Read each statement, think about it, and mark the response which best represents your feelings with regard to the statement. Five possible responses are listed for each item.

---

1. I enjoy playing games that involve some intellectual challenge.

_____always
_____usually
_____sometimes
_____seldom
_____never

2. A person should not mind taking a chance on making a mistake when solving a mathematics problem.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

3. I encourage my students to check their answers to problems to see if the answers actually make sense.

_____always
_____usually
_____sometimes
_____seldom
_____never

4. I tend to think of mathematics problems as being more like games than hard work.

_____always
_____usually
_____sometimes
_____seldom
_____never

5. Mathematics problems are something that I enjoy a great deal.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

6. I do not particularly enjoy thinking about mathematics problems outside of school.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

7. Mathematics problems, generally, are very interesting.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

8. I like to stress with my students that there are often many different ways to solve the same problem.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

9. With sufficient time I believe I could be successful at solving most mathematics problems.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

10. I find solving mathematics problems to be dull and boring.

_____always
_____usually
_____sometimes
_____seldom
_____never

11. I do not particularly like doing difficult mathematics problems.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

12. Trying to discover the solution to a new type of mathematics problem is an exciting experience.

_____always
_____usually
_____sometimes
_____seldom
_____never

13. I find it difficult to concentrate on mathematics problems for a very long period of time.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

14. I often find myself unable to think clearly when trying to solve mathematics problems.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

15. Most mathematics problems, other than the simplest types, take too long to solve.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

16. I enjoy solving puzzles.

_____always
_____usually
_____sometimes
_____seldom
_____never

17. I have trouble understanding why some students think mathematics problems are fun.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

18. I enjoy working on a tricky mathematics problem.

_____always
_____usually
_____sometimes
_____seldom
_____never

19. I believe I am as successful at solving mathematics problems as most other teachers I know.

_____always
_____usually
_____sometimes
_____seldom
_____never

20. I would rather have someone tell me how to solve a difficult problem than to have to work it out for myself.

_____always
_____usually
_____sometimes
_____seldom
_____never

21. One might say that I have a fear of solving mathematics problems.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

22. I consider mathematics problems to be a form of drudgery.

_____always
_____usually
_____sometimes
_____seldom
_____never

23. I am challenged by mathematics problems that I cannot immediately solve.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

24. I think students should be encouraged to use the method that suits them best when solving a problem.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

25. Mathematics problems make me feel as though I am lost in a jungle of numbers and cannot find my way out.

_____always
_____usually
_____sometimes
_____seldom
_____never

26. Regardless of how much effort I put forth, I experience a feeling of confusion when solving mathematics problems.

_____always
_____usually
_____sometimes
_____seldom
_____never

27. I like to encourage my students to adopt a stop-and-think attitude when solving problems.

_____always
_____usually
_____sometimes
_____seldom
_____never

28. The number of rules one must learn in mathematics makes solving problems difficult.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

29. I encourage my students to use trial-and-error procedures when solving many mathematics problems.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

30. I have difficulty making myself think about a problem long enough to solve it.

_____always
_____usually
_____sometimes
_____seldom
_____never

31. I like to emphasize with my students that, in mathematics, some problems have many answers, and some problems have no answer.

_____always
_____usually
_____sometimes
_____seldom
_____never

32. It is a waste of time to draw a figure to help solve a mathematics problem.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

33. Most mathematics problems are frustrating.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

34. Knowing how to compute is about all that is necessary for students to be able to solve most mathematics problems in elementary school.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

35. If I cannot solve a problem right away, I like to stick with it until I have it solved.

_____always
_____usually
_____sometimes
_____seldom
_____never

36. The development of computational skills should take precedence over the development of problem solving skills in the teaching of elementary school mathematics.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

37. The feeling that I have toward mathematics problems is a pleasant feeling.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

38. If I cannot solve a problem right away, I tend to give up.

_____always
_____usually
_____sometimes
_____seldom
_____never

39. I makes me nervous to think about having to solve difficult mathematics problems.

_____always
_____usually
_____sometimes
_____seldom
_____never

40. Students who do not see how to solve a problem right away should be encouraged to try and think of another problem like that one.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

Time 2

NAME________________________________

SCHOOL______________________________

What DMP topics have you covered this school year?

TEACHER SCALE

Experimental Copy

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Center Contract No. NE-C-00-3-0065

On this and the following pages are some statements related to mathematical problem solving. Read each statement, think about it, and mark the response which best represents your feelings with regard to the statement. Five possible responses are listed for each item.

---

1. It is a waste of time to draw a figure to help solve a mathematics problem.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

2. I find solving mathematics problems to be dull and boring.

_____always
_____usually
_____sometimes
_____seldom
_____never

3. I enjoy solving puzzles.

_____always
_____usually
_____sometimes
_____seldom
_____never

4. I consider mathematics problems to be a form of drudgery.

_____always
_____usually
_____sometimes
_____seldom
_____never

5. I am challenged by mathematics problems that I cannot immediately solve.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

6. A person should not mind taking a chance on making a mistake when solving a mathematics problem.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

7. I encourage my students to use trial-and-error procedures when solving many mathematics problems.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

8. Mathematics problems are something that I enjoy a great deal.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

9. Most mathematics problems, other than the simplest types, take too long to solve.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

10. I enjoy playing games that involve some intellectual challenge.

_____always
_____usually
_____sometimes
_____seldom
_____never

11. I believe I am as successful at solving mathematics problems as most other teachers I know.

_____always
_____usually
_____sometimes
_____seldom
_____never

12. I think students should be encouraged to use the method that suits them best when solving a problem.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

13. I encourage my students to check their answers to problems to see if the answers actually make sense.

_____always
_____usually
_____sometimes
_____seldom
_____never

14. I tend to think of mathematics problems as being more like games than hard work.

_____always
_____usually
_____sometimes
_____seldom
_____never

15. I often find myself unable to think clearly when trying to solve mathematics problems.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

16. I would rather have someone tell me how to solve a difficult problem than to have to work it out for myself.

_____always
_____usually
_____sometimes
_____seldom
_____never

17. Trying to discover the solution to a new type of mathematics problem is an exciting experience.

_____always
_____usually
_____sometimes
_____seldom
_____never

18. I like to stress with my students that there are often many different ways to solve the same problem.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

19. Mathematics problems make me feel as though I am lost in a jungle of numbers and cannot find my way out.

_____always
_____usually
_____sometimes
_____seldom
_____never

20. Students who do not see how to solve a problem right away should be encouraged to try and think of another problem like that one.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

21. I have difficulty making myself think about a problem long enough to solve it.

_____always
_____usually
_____sometimes
_____seldom
_____never

22. I have trouble understanding why some students think mathematics problems are fun.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

23. One might say that I have a fear of solving mathematics problems.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

24. I like to emphasize with my students that, in mathematics, some problems have many answers, and some problems have no answer.

_____always
_____usually
_____sometimes
_____seldom
_____never

25. I find it difficult to concentrate on mathematics problems for a very long period of time.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

26. If I cannot solve a problem right away, I like to stick with it until I have it solved.

_____always
_____usually
_____sometimes
_____seldom
_____never

27. I do not particularly like doing difficult mathematics problems.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

28. Most mathematics problems are frustrating.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

29. I enjoy working on a tricky mathematics problem.

_____always
_____usually
_____sometimes
_____seldom
_____never

30. Mathematics problems, generally, are very interesting.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

31. The feeling that I have toward mathematics problems is a pleasant feeling.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

32. I like to encourage my students to adopt a stop-and-think attitude when solving problems.

_____always
_____usually
_____sometimes
_____seldom
_____never

33. I do not particularly enjoy thinking about mathematics problems outside of school.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

34. Regardless of how much effort I put forth, I experience a feeling of confusion when solving mathematics problems.

_____always
_____usually
_____sometimes
_____seldom
_____never

35. If I cannot solve a problem right away, I tend to give up.

_____always
_____usually
_____sometimes
_____seldom
_____never

36. The number of rules one must learn in mathematics makes solving problems difficult.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

37. It makes me nervous to think about having to solve difficult mathematics problems.

_____always
_____usually
_____sometimes
_____seldom
_____never

38. The development of computational skills should take precedence over the development of problem solving skills in the teaching of elementary school mathematics.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

39. With sufficient time I believe I could be successful at solving most mathematics problems.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

40. Knowing how to compute is about all that is necessary for students to be able to solve most mathematics problems in elementary school.

_____really agree
_____agree
_____can't decide
_____disagree
_____really disagree

APPENDIX E

ITEM ANALYSES FOR ATTITUDE SCALES

```
                              UNIVERSITY OF WISCONSIN
                              DEPARTMENT OF SOCIOLOGY
                               ITEM ANALYSIS PACKAGE
                    D. WHITAKER
       Time 1:  ITEM ANALYSIS FOR SCORE  1: PART 1

CRONBACHS ALPHA =  .8470

STANDARD ERROR OF MEASUREMENT       3.284

ITEM TO TOTAL CORRELATIONS

            1        2        3        4        5        6        7        8        9       10
       .67645   .72154   .41140   .71965   .70301   .54012   .56789   .63703   .62922   .62213

           11       12
       .71197   .33376


CURETON CORRECTED ITEM TO TOTAL CORRELATIONS

            1        2        3        4        5        6        7        8        9       10

       .60567   .64865   .29901   .66018   .60119   .43701   .46668   .54132   .54429   .53990

           11       12

       .63065   .23723
```

```
                          UNIVERSITY OF WISCONSIN
                          DEPARTMENT OF SOCIOLOGY
                          ITEM ANALYSIS PACKAGE
          D. WHITAKER
Time 1:   ITEM ANALYSIS FOR SCORE  2: PART 2

CRONBACHS ALPHA =  .8174

STANDARD ERROR OF MEASUREMENT =    5.496

ITEM TO TOTAL CORRELATIONS

       -13      14     -15      16      17     -18      19     -20      21     -22
    .36409  .27864  .54629  .27339  .23500  .52349  .15589  .39366  .41869  .57428

        23     -24     -25     -26     -27      28     -29     -30     -31     -32
    .34825  .60202  .67209  .60902  .68285 -.05927  .62724  .57254  .58309  .48515

        33      34     -35     -36
    .32421  .28487  .57886  .43452


CURETON CORRECTED ITEM TO TOTAL CORRELATIONS

       -13      14     -15      16      17     -18      19     -20      21     -22

    .27311  .20627  .46580  .17515  .12987  .46642  .07176  .30930  .32250  .50715
        23     -24     -25     -26     -27      28     -29     -30     -31     -32

    .28620  .53751  .62262  .55035  .63461 -.15339  .57207  .51063  .51835  .40426
        33      34     -35     -36

    .23875  .20969  .50555  .35063
```

```
                              UNIVERSITY OF WISCONSIN
                              DEPARTMENT OF SOCIOLOGY
                               ITEM ANALYSIS PACKAGE
                  D. WHITAKER
     Time 1:  ITEM ANALYSIS FOR SCORE  3: PART 1 PLUS PART 2

CRONBACHS ALPHA =  .8792

STANDARD ERROR OF MEASUREMENT =     6.551

ITEM TO TOTAL CORRELATIONS

        1        2        3        4        5        6        7        8        9       10
   .60093   .60375   .34032   .64016   .61991   .43701   .42228   .49798   .49144   .51563

       11       12      -13       14      -15       16       17      -18       19      -20
   .56466   .25107   .31705   .30375   .50376   .28116   .26199   .43876   .19519   .35689

       21      -22       23      -24      -25      -26      -27       28      -29      -30
   .47801   .50430   .33089   .60085   .61853   .55147   .60883  -.07934   .56154   .49473

      -31      -32       33       34      -35      -36
   .51571   .40790   .31632   .29507   .52208   .36926


CURETON CORRECTED ITEM TO TOTAL CORRELATIONS

        1        2        3        4        5        6        7        8        9       10

   .56554   .56246   .28970   .60859   .56447   .38766   .37111   .44766   .44646   .47906

       11       12      -13       14      -15       16       17      -18       19      -20

   .51715   .20726   .25379   .25554   .44590   .21519   .19182   .39514   .13869   .29831

       21      -22       23      -24      -25      -26      -27       28      -29      -30

   .41775   .45308   .28829   .55679   .57879   .50643   .56774  -.14389   .51792   .44679

      -31      -32       33       34      -35      -36

   .46617   .34845   .25841   .24455   .46739   .30923
```

```
                                  UNIVERSITY OF WISCONSIN
                                  DEPARTMENT OF SOCIOLOGY
                                   ITEM ANALYSIS PACKAGE
                            D WHITAKER  **** TEACHER ATTITUDES
     Time 1:     ITEM ANALYSIS FOR SCORE  1: TEACHER ATTITUDE

A CONSTANT OF  120 HAS BEEN ADDED TO THIS SCORE

CRONBACHS ALPHA =  .7985

STANDARD ERROR OF MEASUREMENT =     4.255

ITEM TO TOTAL CORRELATIONS

        1          2          3          4          5         -6          7          8          9        -10
    .17901     .06645     .42720     .02457     .47246     .49972     .30216     .35550     .45343     .44945

      -11         12        -13        -14        -15         16        -17         18         19        -20
    .34173     .25569     .16737     .42666     .17299     .32727     .13703     .64314     .66262     .60199

      -21        -22         23         24        -25        -26         27        -28         29        -30
    .51145     .36748     .42769     .19459     .76690     .51115     .37370     .18695     .08632     .45335

       31        -32        -33        -34         35        -36         37        -38        -39         40
    .47949     .04674     .40226     .15601     .48939     .41525     .09064     .56531     .63869    -.07429


CURETON CORRECTED ITEM TO TOTAL CORRELATIONS

        1          2          3          4          5         -6          7          8          9        -10

    .11072    -.02578     .36972    -.07829     .40261     .43914     .25378     .28155     .38416     .40623

      -11         12        -13        -14        -15         16        -17         18         19        -20

    .24951     .18601     .10188     .38527     .12676     .24804     .08968     .60485     .61097     .55915

      -21        -22         23         24        -25        -26         27        -28         29        -30

    .46680     .32167     .38512     .13268     .74890     .46939     .31186     .12296    -.01337     .40530

       31        -32        -33        -34         35        -36         37        -38        -39         40

    .39541    -.01251     .37091     .07766     .44784     .30884    -.00732     .53253     .59272    -.13225
```

```
                              UNIVERSITY OF WISCONSIN
                              DEPARTMENT OF SOCIOLOGY
                              ITEM ANALYSIS PACKAGE
                 D. WHITAKER
   Time 2:   ITEM ANALYSIS FOR SCORE  1: PART 1

A CONSTANT OF     0 HAS BEEN ADDED TO THIS SCORE

CRONBACHS ALPHA =  .8664

STANDARD ERROR OF MEASUREMENT =     3.267

ITEM TO TOTAL CORRELATIONS

          1       2       3       4       5       6       7       8       9      10
     .72930  .35532  .54071  .74225  .59318  .69728  .67021  .45171  .72142  .73119

         11      12
     .71938  .69962


CURETON CORRECTED ITEM TO TOTAL CORRELATIONS

          1       2       3       4       5       6       7       8       9      10

     .64827  .25728  .45504  .67115  .50745  .61860  .46219  .37290  .65997  .66150

         11      12

     .65591  .62097
```

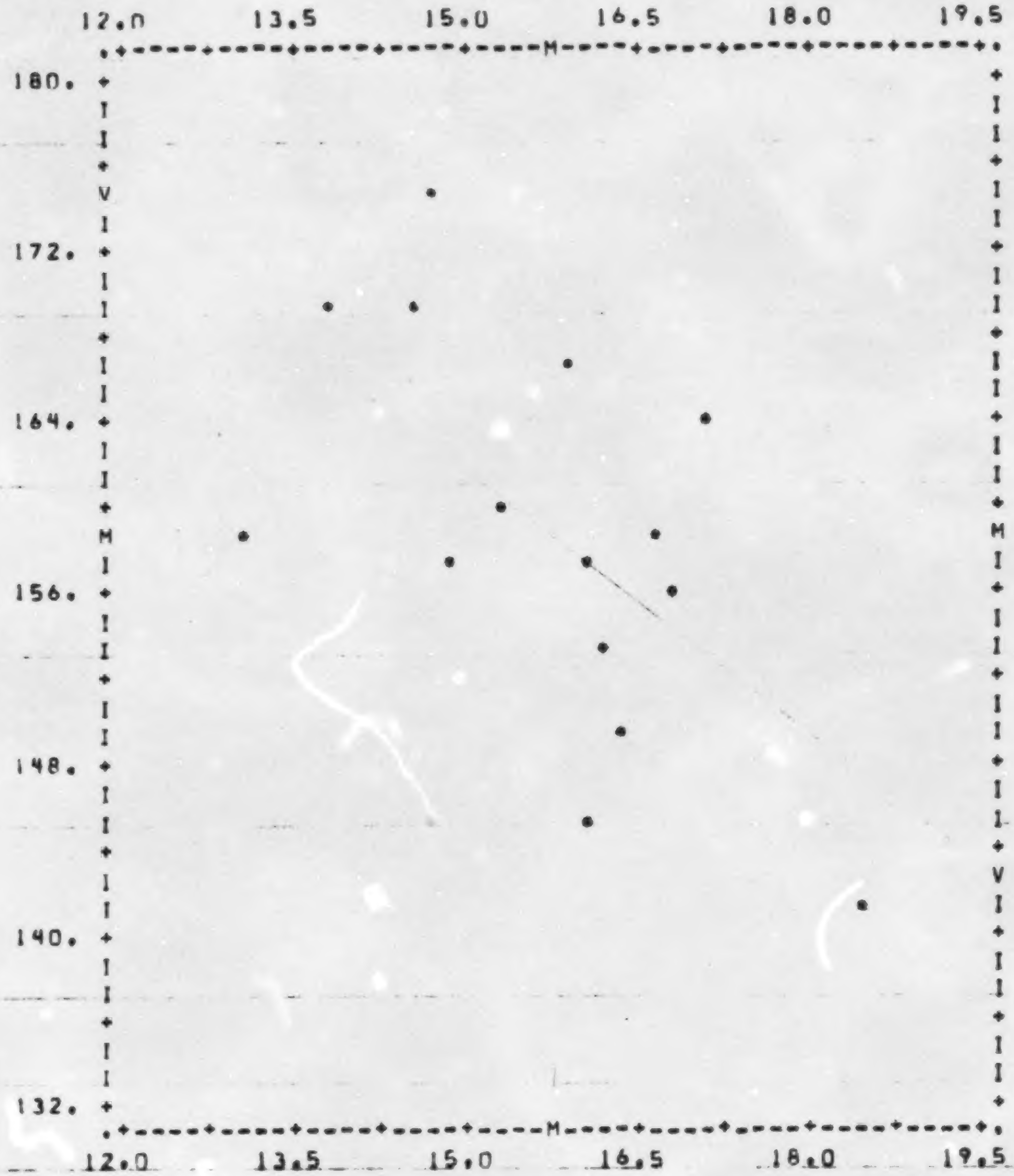
```
                                   UNIVERSITY OF WISCONSIN
                                   DEPARTMENT OF SOCIOLOGY
                                    ITEM ANALYSIS PACKAGE
                     D. WHITAKER
Time 2:            ITEM ANALYSIS FOR SCORE  2: PART 2

A CONSTANT OF     0 HAS BEEN ADDED TO THIS SCORE

CRONBACHS ALPHA =  .8523

STANDARD ERROR OF MEASUREMENT =    5.381

ITEM TO TOTAL CORRELATIONS

         -13       14       15       16      -17      -18      -19      -20       21       22
       .53759   .02420   .26077   .32230   .60771   .65121   .61409   .39472   .36353   .15919

         -23       24      -25       26      -27      -28      -29       30       31      -32
       .62663   .56814   .66215   .16680   .45663   .51278   .66278   .39929   .43606   .47429

         -33      -34      -35      -36
       .59889   .68048   .68510   .67228


CURETON CORRECTED ITEM TO TOTAL CORRELATIONS

         -13       14       15       16      -17      -18      -19      -20       21       22

       .49699  -.07164   .16242   .25061   .54971   .60300   .56294   .30201   .27786   .07992

         -23       24      -25       26      -27      -28      -29       30       31      -32

       .57158   .49816   .60940   .09054   .39079   .49981   .61213   .32041   .38532   .39978

         -33      -34      -35      -36

       .53339   .63137   .64264   .62526
```

```
                                  UNIVERSITY OF WISCONSIN
                                  DEPARTMENT OF SOCIOLOGY
                                   ITEM ANALYSIS PACKAGE
                           D. WHITAKER
Time 2:               ITEM ANALYSIS FOR SCORE  3: PART 1 PLUS PART 2
--------------------------------------------------------------------------------------------------------
A CONSTANT OF     0 HAS BEEN ADDED TO THIS SCORE

CRONBACHS ALPHA =  .9053

STANDARD ERROR OF MEASUREMENT =     6.432
--------------------------------------------------------------------------------------------------------
ITEM TO TOTAL CORRELATIONS

            1        2        3        4        5        6        7        8        9       10
        .62983   .27665   .51407   .63510   .49624   .56939   .47242   .36836   .61476   .60843

           11       12      -13       14       15       16      -17      -18      -19      -20
        .65757   .63731   .52303   .00960   .30183   .32177   .54149   .61429   .56550   .33211

           21       22      -23       24      -25       26      -27      -28      -29       30
        .37408   .15199   .57741   .59597   .63075   .13996   .39959   .48922   .64752   .35920

           31      -32      -33      -34      -35      -36
        .41131   .42256   .54266   .68564   .61948   .63670


CURETON CORRECTED ITEM TO TOTAL CORRELATIONS
--------------------------------------------------------------------------------------------------------
            1        2        3        4        5        6        7        8        9       10

        .58826   .23400   .47808   .59667   .45606   .52761   .42324   .33313   .58166   .56982

           11       12      -13       14       15       16      -17      -18      -19      -20

        .62707   .60087   .49511  -.05478   .23811   .27424   .49776   .57881   .52773   .26808

           21       22      -23       24      -25       26      -27      -28      -29       30

        .31802   .09907   .53664   .55211   .59240   .08883   .35327   .44607   .61202   .30531

           31      -32      -33      -34      -35      -36

        .37660   .37045   .49459   .65294   .58518   .60179
```

APPENDIX F

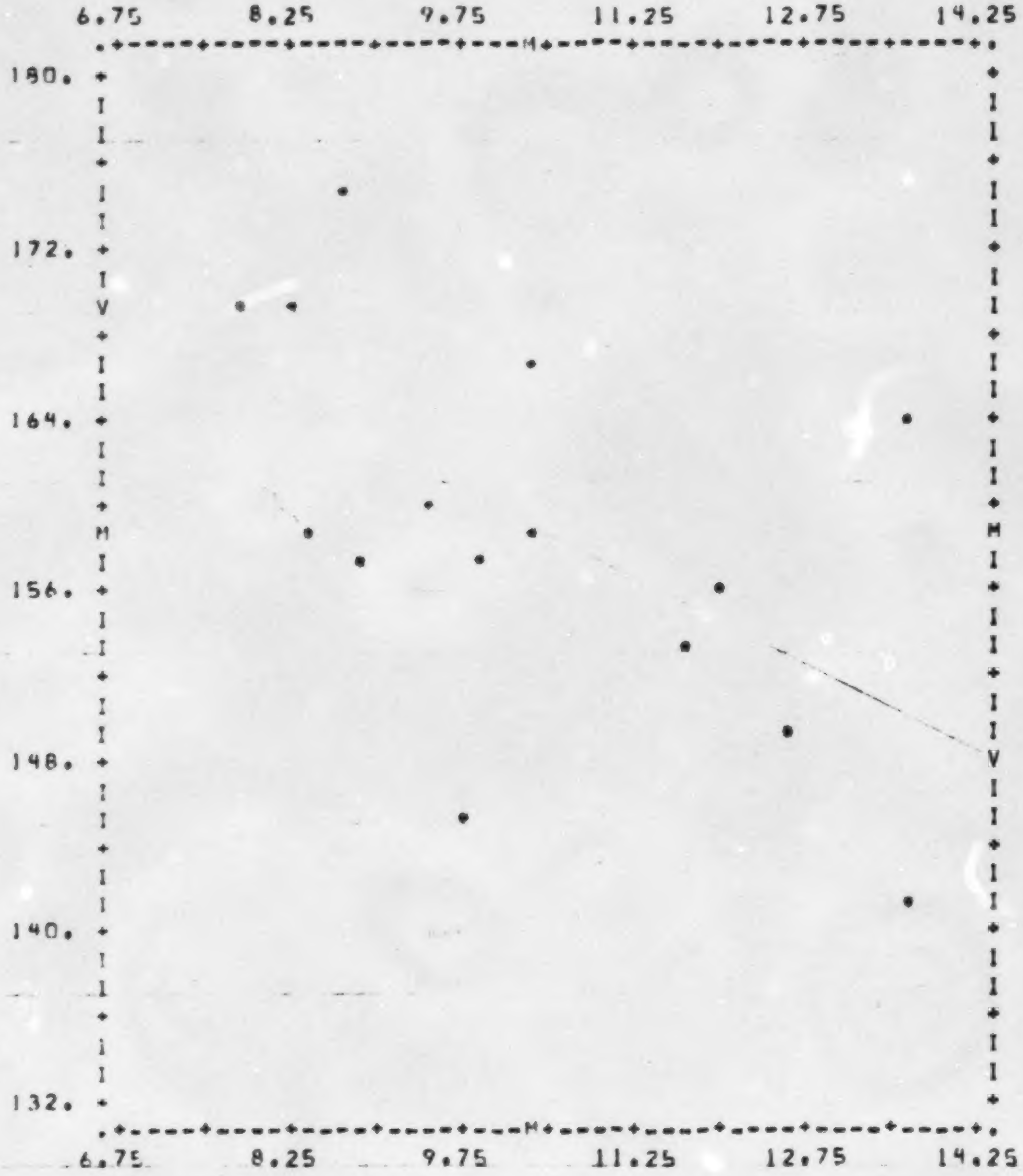
SCATTER PLOTS FOR QUESTION 5

```
SCAT 1-13
HORIZONTAL: Student Comprehension Scores
  VERTICAL: Teacher Problem Solving Attitude Scores
```



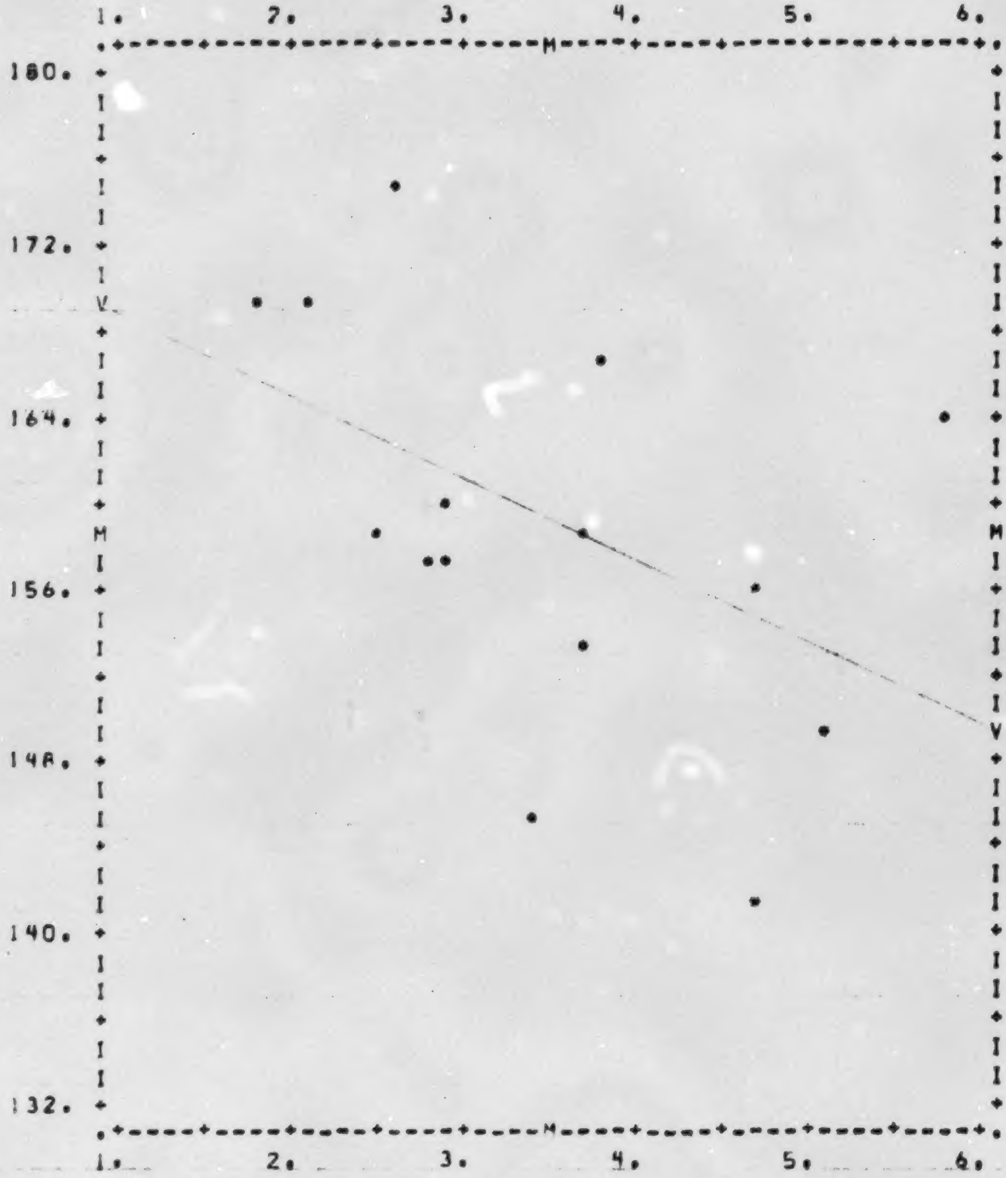
```
15 POINTS ARE INCLUDED IN THE SCALED PLOT
CORRELATION R = -.590,  T(13) = -2.63,  SIG. PROB. = .021

      MEAN     STD. DEV.       REGRESSION LINE           S.E. REG.
H   15.733     1.371
V   158.87     9.357     V= 222.16356 - 4.02313*H     7.843
```

SCAT 1-15
HORIZONTAL: Student Application Scores
VERTICAL: Teacher Problem Solving Attitude Scores



```
15 POINTS ARE INCLUDED IN THE SCALED PLOT
CORRELATION R = -.549,  T(13) = -2.37,  SIG. PROB. = .034

     MEAN    STD. DEV.      REGRESSION LINE           S.E. REG.
H  10.343     1.940
V  158.87     9.357     V= 186.24061 - 2.64653*H     8.117
```

```
SCAT 1-17
HORIZONTAL:  Student Problem Solving Scores
  VERTICAL:  Teacher Problem Solving Attitude Scores
```



```
15 POINTS ARE INCLUDED IN THE SCALED PLOT
CORRELATION R = -.471,  T(13) = -1.92,  SIG. PROB. = .077

     MEAN    STD. DEV.      REGRESSION LINE          S.E. REG.
H  3.4975     1.156
V  158.87     9.357     V= 172.19018 - 3.8094*H       8.567
```

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